French and German Experiments Against Chilled Cast-Iron Armor.*

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On the 7th, 8th and 9th of April, 1884, experiments took place at St. Chamond (France) against chilled cast-iron, compound, and wrought-iron armor, the results of which were considered by the press as a decided victory in favor of wrought-iron armor.

Although the experiments do not now permit of an entire and accurate conclusion to be drawn, because the quality of the chilled cast-iron made by the Chamond Works is to the present quite unknown in Germany, still in one respect they are of great interest, as they again show what influence the vault-shaped form of the armor has upon its resisting power.

This influence seems at first to be somewhat self-evident, for, as the angle of incidence of the projectile essentially depends on the curved surface of the armor, it is evident that that armor surface is the best which offers the smallest angle of incidence.

This entirely natural conclusion is nevertheless in a surprising manner refuted by all the experiments so long as chilled cast-iron projectiles have been used; these shells, when striking nearly normally, were shivered into atoms, whilst when striking obliquely they broke up in large pieces which more or less injured the armor plate and always caused a number of hair cracks.[1]

Perhaps the profile of the French armor, which we shall describe later on, owes its origin to those observations, for it seems to be so calculated as to enable the guns in any position before the armor to give normal hits.

Now the experiments were not made with chilled cast-iron shells but with steel projectiles, which when fired mostly remained entire, and this completely alters the matter, as a nearly infrangible projectile, which strikes the plate with almost its total striking energy, will give better results with a normal hit than with an oblique one.

Thus, on account of the present extraordinary improvements in steel projectiles, the proper theoretical proportion between armor and projectile is only now re-established; but a mistake would be made if the component of the striking energy which really has effect on the armor should be calculated in proportion with the sine of the angle of impact, for the causes of the effect are more complex.

A proper idea of the effect of the projectiles in oblique fire can only be obtained by continued firing experiments, and we shall for this reason give the description of the French experiment with normal fire in comparison to that of two German experiments with oblique fire.

*Translated from the "Neue Militarischer Blatter."

[1] See the "Mittheilungen des Ingenieur-Komite's," No. 22 (1877,) pages 24, 25, 28, also "Neue Militarische Blatter," January, 1884, page 84.

I. THE EXPERIMENT AT ST. CHAMOND ON APRIL 7TH, 8TH, AND 9TH, 1884.

The targets were three armor plates, of chilled cast-iron, rolled iron, and compound metal, all manufactured at the St. Chamond Works.

The chilled cast-iron armor corresponds to an embrasure plate of a casemate (see "Aide Mémoire," 1883, chapter xiii., page 18.) The plate (Fig. 1) had the shape of a hollow cylinder segment covered at the top, and the convex surface went in a somewhat sharp curve into the flat arching of the cover.

The profile of the surface to be fired at formed, as Fig. 1 shows, a straight vertical line whereby the angles of impact are always obtained near to 90 deg.

The two other plates were parts of cylindrical turrets of about 2 m. outside radius. All three plates were built in casemates and supported in a solid manner. The dimensions can be seen from the following Table:

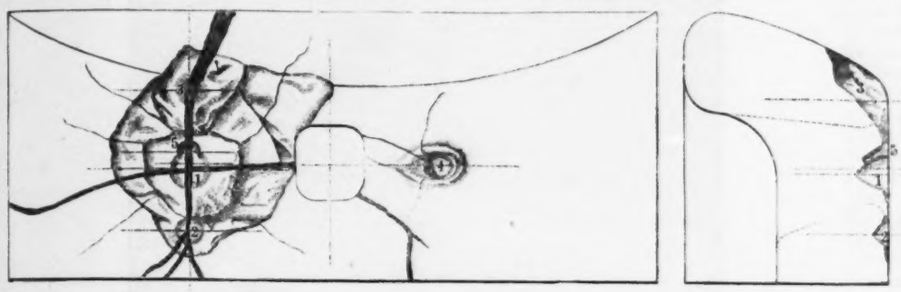

FIG. 1.

The Plate.	Chilled Cast Iron.	Compound.	Rolled Iron.
Shape	As described	Hollow cylinder segment 1.9 m. radius.	Hollow cylinder segment 2 m. radius.
Thickness	600 mm.	Total 320 mm. and 110 mm. steel.	450 mm.
Width	3.6 m.	2.75 m.	3.7 m.
Length of developed curve	5 m.	3 m.	5 m.
Height	1.45 m.	1.2 m.	1.2 m.
Weight	23,000 kilos.	9370 kilos.	21,775kilos.

Gun used, long 15.5 cm. on siege gun carriage; projectile, tempered shell of special steel from the St. Chamond Works; weight, 41 kilos.; distance, 15 m.; charge, 9 kilos. powder S.P.; velocity. 465 m.; striking energy, 453 meter tons.

(a) Firing against the Chilled Cast-Iron Armor Plate.—The first three rounds were fired at an angle of incidence of 90 deg. on a vertical line 77 cm. to the left of center of embrasure; the first hit as high as the embrasure center, the second 35 cm. under the first, and the third 43 cm. above the first.

Round 1 caused five slight hair cracks, which were enlarged by round 2, while round 3 divided the plate in two parts by a vertical crack passing through the three points of impact.

Round 4 was fired at an angle of incidence of 75 deg.; 60 cm. to the right of, and as high as, the center of embrasure. The result was three slight hair cracks, and another which was commenced under the right corner of the embrasure and prolonged downwards towards the right. It terminated 20 cm. from the lower edge of the embrasure.

Round 5 struck at an angle of incidence of 90 deg., 10 cm. above the first.

The embrasure crack caused by the fourth round was prolonged in a sharp curve to the lower edge of the plate. A horizontal crack extended from the embrasure through the point of impact No. 1 to the left edge of the plate. The plate was divided (brisée) into four pieces by these cracks. The indents caused by two rounds were 170 mm. to 175 mm. deep, those by the other rounds 70 mm. to 83 mm. Two projectiles remained entire, the ogival part of two broke, and one (No. 4) was crushed.

(b) Firing against the Compound Plate.—Two rounds were fired at the compound plate. The point of impact was on a vertical line 68 cm. to the right of center line.

Round 1.—The projectile penetrated 14 cm. deep through the steel surface and remained there intact, while in the wrought-iron layer a vertical crack was visible through its whole thickness from the upper to the lower edge.

Round 2 struck 13 cm. deep; the plate then was split in two parts.

(c) Firing against the Wrought-Iron Plate.—Thirteen rounds in all were fired at the wrought-iron plate, and, with the exception of two, struck on a vertical 60 cm. near to the left of the center line. The first three rounds penetrated 205 mm., 200 mm., and 195 mm. deep. The fourth round increased the depth of the indent on the middle of the vertical, caused by the first round, to 220 mm., the point broke off and remained in the plate. Rounds 5 and 6 did not enlarge this penetration, as the projectile broke in striking the pieces of the other shells in the plate.

Round 7 hit between the second and first rounds, and penetrated 350 mm. Three haircracks from 10 cm. to 30 cm. long were produced on the back of the plate.

Round 8 increased the indent of the first, fourth, fifth, and sixth rounds to 300 mm.

Round 9 caused three short cracks on the back, the ogival part of the projectile remained in the plate and was removed by the tenth round, which at the same time increased the indent to 340 mm.; the width of the cracks on the back of the plate was increased to 30 mm.

The eleventh round struck on the same place, pierced through and tore a round piece from the back of the plate 50 cm. in diameter, and 5 cm. thickness in the thickest part.

Rounds 12 and 13 were fired with an angle of incidence of 75 deg. and 65 deg. on the left side of the plate.

Result: Slight indents. The projectiles broke up.

In the report before us of the above experiments at the St. Chamond Works, it is concluded that chilled cast-iron armor could not resist, even a short time, normal and oblique fire; that the compound plates were good for ships when they are provided with wood backing, but not for turrets and casemates. It is said that the only efficient means to protect the latter were rolled iron plates of the same quality as made by the St. Chamond Works.

We, for our own part, have very few words to add relative to these conclusions. It was hitherto the rule in experiments to try such armor and ordnance against each other as were in good proportion, as only under such circumstances can results be arrived at demonstrating the effectiveness of both. The St. Chamond Works have made an exception to this rule, as they fired with a 15.5 cm. gun against a rolled iron plate 45 cm. thick, while an armor plate 30 cm. thick would have sufficiently resisted that kind of projectile. They exposed this plate to a severe trial, as seven rounds were concentrated on one point, but the severity of this experiment is only apparent, as three rounds struck on pieces of old projectiles, in which case the result, according to experience, is a minimum one. Had the rounds struck in the neighborhood of the point of impact, the effect would have perhaps been greater, as the seventh round shows (350 mm. penetration), and a breach quicker attained. We mention this *en passant*, not doubting at all that the plate was of a very good quality.

As, however, part of the press represent the behavior of the wrought-iron plate as extraordinary, we must oppose this opinion, and cannot help saying that these critics lack the necessary knowledge of the numerous results obtained on practice grounds against armor.

Similar results as those at St. Chamond take place whenever there is an excess of strength on the side of the plate, and, although the experiments carried out on this basis are not numerous, it is always possible to mention a few where the relation between the effect of gun and the security given by the armor was such that only a great number of hits on a small surface were able to effect a breach. We beg to remind our readers of the experiment in 1866 at Mayence against Schuman's gun carriage. [2]

One of Brown's rolled iron plates 6 in.(15 cm.) thick required to be fired at with fifty-one chilled cast-iron and steel projectiles out of the 15 cm. gun, with a charge of 6 lb.; before a breach could be made the projectiles were concentrated on a surface of 1 gm. The small energy of the 15 cm. projectile then used gave the proportional thin plate a similar excess of strength, as noticed at St. Chamond. The results of the following experiments were more advantageous. In 1870 a Cammel's front plate of a turret was fired at by a 15 cm. gun with a 6 lb. charge. [3] The thickness of the plate, apart from a backing behind of 12 cm., was 21 cm. Seventy-four rounds which struck it in groups failed to breach the front plate, and only later on was it possible to make a breach in the weaker side plate. The relation between effect and protection was about the same as at St. Chamond.

We mention these experiments as examples, so as to avoid the erroneous idea that the trials of St. Chamond have been an important occurence for rolled iron armor; they only confirm the results of experiments long since known. Nevertheless we willingly agree that the St. Chamond rolled iron plate was a very good one, as it must be, being of the small height of 1.2 m. This considerably facilitated its manufacture, and we are now of opinion that both the above-named English firms or the Dillinger Works are capable at any time of supplying plates of the same quality. This favorable opinion cannot of course be expressed concerning the compound plate. That the whole wrought-iron layer, which generally remains entire up to the last, of a compound plate 320 mm. thick, should be torn by a single projectile out of the 15.5 cm. gun, is very remarkable,and that the steel layer remained entire until the second round, alters the opinion only a little in favor of the plate.

Even the omission of the wood backing does not explain the effect of such a shot, and we think we are therefore entitled to say of this experiment that plates of such quality are not applicable for turrets or ships. With respect to the chilled cast iron we have already partly given our opinion; the profile of the plate was most unsuitable and evidently calculated for projectiles of cast iron. But even then the constructor has not chosen a suitable shape for the armor, for the plate must at least have so much curvature that broken pieces of it remain in their places by reason of their own weight and are not caused to fall off by concussions on or vibrations of the plate. As soon as the curved surface of the plate is relinquished the chief advantages of chilled cast-iron armor are abandoned and then of course the wrought iron plate is to be preferred. Finally, the extraordinary soft material of the chilled cast-iron plate is remarkable: a penetration of 175 mm., and even any true penetration of the projectile (see the profile, Fig. 1) has not yet been observed with chilled cast-iron armor. Holes or indents, as if chiselled in the surface have often occurred, but they have never accorded with the shape of the projectile.

At St. Chamond, however, the first projectile penetrated the chilled cast-iron armor the same as if it was a rolled iron plate, and from this we conclude that surely the material was too soft.

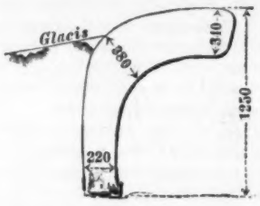

Fig. 2.

Speaking of the conclusions which the St. Chamond Works draw from these experiments it is astonishing that power of resistance is denied to chilled cast-iron armor under an oblique fire. When we reflect that only one oblique shot at an angle of incidence of 75 deg. struck the plate which caused three slight cracks it then seems that that decision is nevertheless a hazardous one. The effects of oblique fire require, according to our opinion, especially with chilled cast-iron armor, an especial study, and to demonstrate this we subjoin two official reports of German experiments, whose results differ so far from the experiments at St. Chamond that they require no comment.

II. TRIAL AGAINST THE FRONT PLATE OF A CHILLED CAST-IRON TURRET FOR TWO 12 CM. GUNS, AT MR. GRUSON'S PRACTICE GROUND AT BUCKAU-MAGDEBURG ON FEBRUARY 12, 1884.

Target (Figs. 2 and 3).—The front plate, weighed 10,700 kilos., and was fixed between two wrought-iron plates backed with brickwork. The maximum thickness of the plate radially measured was 380 mm., the height 1250 mm., the width of the curve below was 3159 mm., and above, 2269 mm. The outside diameter of the front armor to which the trial plate belonged was 7280 mm. The bottom part of the plate was covered with a glacis composed of granite, as shown by the drawing. Protection against rebounding splinters was provided in the usual way by a screen of wood covered with earth.

Object of the trial.—To try the plate by firing five rounds out of the 15 cm. Italian gun in order to prove if it had the proper dimensions for this armor. Gun, Italian 15 cm., G. R. C. (ret,) mounted on a Gruson's minimum embrasure carriage c. 80; projectile, Krupp's steel shell, each projectile weighed 38.7 kilos; charge, 7.4 kilos. Fossano powder, 20 mm. to 24 mm.; distance, 45 m.; initial velocity, about 415 m.; striking energy, about 345 meter-tons.

Round 1.—Krupp's steel shell unloaded.

Fig 3.

Depression 2.04 deg. The projectile struck 45 cm. before the armor on the glacis rebounded and grazed the plate 16 cm. over the upper edge of the glacis. Effect, an oblong splash.

Round 2.—Krupp's steel shell unloaded. Depression 2 deg.; point of impact, 281 cm. to the left near the center line, 6 cm. over the upper edge of the glacis; angle of incidence, 41 deg. 25 min. The total result was a bright splash of 5 mm. maximum depth. No hair cracks.

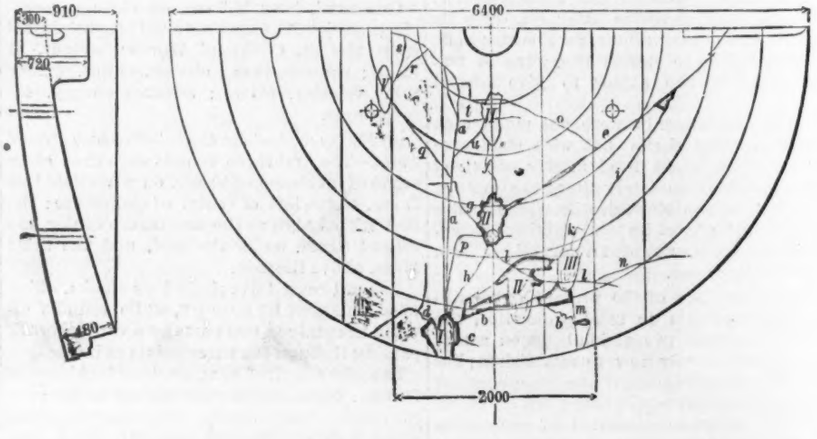

Fig. 4.

Round 3.—Krupp's steel shell unloaded. Point of impact, 28 cm. to the right near the center line, 8 cm. over the upper edge of the glacis; angle of incidence, 38 deg. 40 min. Effect, an indent of 10 mm. maximum depth, four concentrated star-like hair cracks round the point of impact, the length of the longest was 15 cm. Besides this, after the third round two hair cracks of 10 cm. length were observed on the second point of impact.

Round 4.—Krupp's steel shell unloaded. Depression, 2 deg.; point of impact, 32 cm. to the left of the center line, 4 cm. above the

[2] See Brialmont, "Traité de Fortification Polygonale," tome ii., page 283.

[3] See Brialmont, "La Fortification à Fossés secs," tome i., page 230.

upper edge of the glacis; angle of incidence, 40 deg. Effect: The projectile grazed the upper edge of the glacis and caused a hole in the granite 7 cm. deep, also an indent on the plate 10 mm. maximum depth. Four short hair cracks one of which connected the points of impact 4 and 2.

Round 5.—Krupp's steel shell unloaded. Depression, 2 deg.; point of impact, 9 cm. to the right of the center line, 6 cm. above upper edge of the glacis (between hits 2 and 3); angle of incidence, 41 deg. 30 min. Effect: Indent, a sharp chiselling inside of 8 mm. maximum depth, below to the right a slight indent 5 mm. deep. Two fine hair cracks. The effect of the sixth shot seemed to be greater than the others.

SUMMARY.

The resisting power of the plate was thus proved to be quite sufficient and the dimension chosen to be correct. Only one of the small hair cracks could be probed and was found to have an average depth of 30 mm. and a maximum of 45 mm.

The projectiles broke up, the same as in former trials, in small pieces; these were of unusually hard material and a file had no effect upon them.

We forego for the present to compare the results of this and the French experiment, and give the report of another trial, which shows more distinctly the influence of the plate profile and the angle of incidence.

In order to obtain a greater angle of incidence the trial plate was not fixed horizontally but at an inclination of 5 deg. There were a number of small hair cracks in the trial plate which were closed with steel wedges.

Further, there were three holes in the plate 12 cm. in diameter, in which the eyes are fixed for moving the plates. Protection against rebounding shell splinters was provided in the usual manner by a screen of wood covered with earth. Gun, Krupp's 25 calibre long 30.5 cm. mounted on a Gruson's minimum embrasure carriage c. 80; projectile, Krupp's 3.5 calibre long steel shell unloaded, weight about 445 kilos.; charge, 80 kilos. P. P. c. 80; distance, 29 meters; final velocity, 345 meters; striking energy, 2700 meter tons.

Round 1.—Weight of projectile, 443.8 kilos. The gun was fired with 5 deg. 6 min. depression; angle of incidence, 24 deg. 14 min.; point of impact, 50 cm. to the left of the center line, 34 cm., from the round edge of the plate (see Fig. 3.) Effect: Indent 22 mm. deep with scales 58 by 29 greatest extension. A radical crack *a* (Fig. 4) appeared to go through the plate, beginning on the point of impact and extending 62 cm. from the straight edge of the plate. Three hair crack *b*, *c*, *d*. The projectile broke up into numerous pieces, the same as in later experiments.

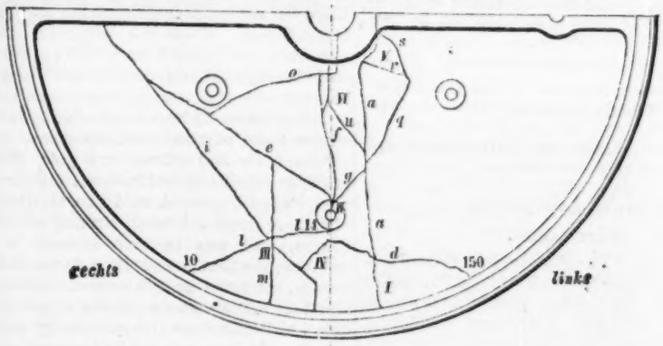

Fig. 5

Round 2.—Weight of projectile, 446.5 kilos.; depression, 4 deg. 25 min.; angle of incidence, 19 deg. 35 min.; point of impact, center line of the middle hole for erecting, and ran in a zigzag to the round edge of the plate. Crack *f* extended nearly radially from the middle hole for erecting purposes to the straight edge of the plate. Length 97 cm. The direction differs considerably from those cracks on the upper side of the plate. Crack *g* visible on the inside as far as crack *a*. A radial crack, which was seen before the firing in the middle plate of the butt ring, was enlarged, and the plate had sunk 1½ mm. Projectile shattered.

Round 3.—Weight of projectile, 444.6 kilos; depression, 4 deg. 42 min.; angle of incidence, 22 deg. 52 min.; point of impact, 72 cm. to the right of the center line, 70 cm. from the round edge of the plate. Effect: An oblong splash. A crack *i* proceeding from the point of impact to the right and running into crack *e*. Three short cracks, *k*, *l*, *m*, the latter proceeded to the round edge of the plate. Crack *a* prolonged upwards towards the left, ran 10 cm. under the straight edge. Inside of the plate: Crack *i* visible in its entire length, crack *l* united with *d* on the inside, separated, as shown in Fig. 5, a segment of the plate. Crack *m* went through the plate, appeared to be united with *k*. Projectile shattered.

Round 4.—Weight of projectile, 445.1 kilos.; depression, 4 deg. 45 min.; angle of incidence, 23 deg. 25 min.; point of impact, 28 cm. from the center line, 45 cm. from the round edge of the plate, between hits one and three. Effect: The shell struck the segment loosened by the third round, and caused, besides a splash, a scaling off on the point of impact upwards, towards hits one and three, as shown in the engraving. New cracks *n*, *o*, *p*, in thin curves to the edge of the plate *h* prolonged as far as point of impact 1. The piece of the plate close to crack *b* was raised on the right hand 35 mm. An examination of the crack showed that it ran in an oblique direction inside of the plate towards the round edge, but was not visible on the back of the plate. Back of the plate: The fourth round had caused no new crack, but the piece circumscribed by the cracks *l* and *d* had sunk. The sinking on the left hand was 150 mm., in the middle 14 mm., and on the right hand 10 mm. The piece separated stuck fast in the joint. Projectile shattered.

As the plate seemed to be still entirely capable of resistance, the trial was continued on 28th of May.

Round 5.—Projectile; Krupp's flat-head shell. Diameter of the flat part, 137 mm.; weight, 445 kilos.; depression 3 deg. 48 min.; angle of incidence, 12 deg. 18 mm.; point of impact, 106 cm. to the left of the center line, 60 cm. from the straight edge of the plate.

Fig. 6

III.—TRIAL AGAINST A HALF OF A COVER PLATE OF A CHILLED CAST-IRON TURRET FOR TWO 30.5 CM. GUNS, AT MR. GRUSON'S PRACTICE GROUND AT BUCKAU-MAGDEBURG ON MAY 26 AND 28, 1884.

Object of the Trial.—To try a half of a cover plate of the armor turret already mentioned by four shots out of a Krupp's 25 calibre long 30.5 cm. gun.

Target (Fig. 6.)—The trial plate of 47,500 kilos weight and 320 mm. smallest thickness. The plate was fixed, according to its position in the turret, in a half ring of strong wrought-iron plates; the other half of the cover plate was supplied by a strong abutment plate backed with brickwork, the ring plates were fastened by means of ribs into a brickwork foundation. the plate, 126 cm. from the round edge of the plate. Effect: The shot struck the middle erecting hole and caused an indent on the upper half 10 cm. deep, round this was a scaling off of 30 cm. by 54 cm. greatest extension and smallest depth.

Crack *b* prolonged itself to the right as far as the round edge of the plate. A new crack *e* proceeded from the point of impact upwards to the right 64 cm. under the straight edge of the plate. Hair crack 40 cm. long, *g* in a sharp curve crossing the crack *a*, *h* 32 cm. long. Back of the plate: Crack *a* showed itself as going through from one edge of the plate to the other, Fig. 5. Crack *e* which ran on the surface of the plate under the straight edge, began on the inside on the straight edge, extended to Effect: An oblong indent 10 mm. deep without scales, three cracks, *q*, *r*, *s*. Back of the plate: The cracks, *q*, *r*, *s*, were also visible at the back. The crack in the middle of the bedplate was enlarged. The piece separated by the cracks *l* and *d* had sunk about 25 mm. deeper, but still stuck fast in the plate. Projectile shattered.

Round 6.—Projectile, Krupp's flat-head steel shell; weight, 445 kilos.; depression, 3 deg. 44 min.; angle of incidence, 13 deg. 14 min.; point of impact, center line of the plate 84 cm. under the straight edge. Effect: An oblong depression without scales; two fine cracks *t* and *u*; crack *f* lengthened. Back of the plate: Crack *f* prolonged to the edge; cracks *o* and *u* visible on the back; the loose piece had not

sunk any deeper; projectile was broken up.

The trial had to be discontinued after the sixth round, as the earth bank for stopping the projectiles had received so much injury that it no longer afforded sufficient security for stopping them.

SUMMARY.

The armor plate had now showed more than sufficient resisting power in case of an attack, as the projectiles could never strike at such a great angle of incidence as in the last trial, and the dimensions chosen proved to be quite sufficient

The advantages of the curved surface were rendered conspicuous; for example, the fourth shot struck a piece already separated from the plate, and could not drive it inside, notwithstanding that the resisting powers of the dome-shaped form were already reduced by the cracks in the ground plate. The sixth shot also struck a piece already separated by cracks without being able to force in inside.

The "chill cracks" proved to have no influence on the resistance of the shield, as the cracks caused by the projectiles were produced and prolonged independent of these.

It was interesting to notice the great influence the angle of incidence had upon the effect of the fire.

The effect of the shot on the base part of the plate was greater than that of rounds 5 and 6, notwithstanding the latter hit the plate when it was in a weaker state.

It appears the projectiles strike with the bottom, as soon as the ogival part has touched the plate, and to this in a great extent may the effect be ascribed, and is all the more violent the greater the angle of incidence.

The greater angle of incidence caused by the slanting of the plate and the depression of the gun should in attack more than equalise the stronger charge of powder. The violent striking of the base of the projectile explains why these were all shattered, which, with the quality of Krupp's steel and the simple deflection on the ogival part would have been surprising.

If objection is made against the firing at the "front" plate, that the energy of the projectiles was 100 metre-tons less than that of the projectiles at St. Chamond (N. B. the German plate was however more than one-third weaker than the French), this objection disappears with regard to the experiment on the cover plate, in which the energy fired against the latter was six times greater than that of the French projectiles. The plate was in its thickest part one-third, and in its weakest part one-half, thinner than that of St. Chamond.

The resistance which the armor opposed to the shots fired against it proved that the latter had a considerable surplus of strength. The cracks remained in consequence of the curved construction—that is, from the pressure thereof, entirely closed, and appeared on the surface to be hair cracks, although they had gone through the entire thickness of the plate. Small separate pieces which were struck by the shots remained fixed with extraordinary firmness in the joints, so that, according to the opinion of the Trial Commissioners, the cracked part of the plate would have been capable of withstanding several shots. The right and left third part of the plate was as good as completely intact, and therefore capable of withstanding a heavy fire. This trial is more than one respect important. As already mentioned, it was thought that glancing shots had an especial destructive effect against chilled cast armor, and the covers were always regarded with mistrust. The trials at Buckau have quite removed these objections, as the diameter of the plate, 6.4 m., was a minimum one compared to the side plate formerly fired at, and it afforded, notwithstanding, a more than sufficient power of resistance. But objection can be raised that at St. Chamond a front plate was fired at, and that the results obtained from the trials against a cover plate can have no relation whatever to the first named.

This objection is correct. In that case an armor dome with a profile where the greatest angle of incidence for the projectile is 24 deg. is not available, because inside it there would be no room for a gun. We have for this reason placed the firing against the "cover" before that of the "front" plate where an angle of incidence of 46 deg. 20 min. took place. If the effect of this shot is considered, then the conviction will be obtained that an angle of incidence of 46 deg. is the most favorable one for the armor. The effect of the five 15 cm. shells fired against the "front" plate consisted only of a few hair cracks hardly visible with the naked eye; one of the last of these hair cracks was measured by a probe and found to be 45 mm. deep. It should also not be forgotten that the upper part of the front armor was not supported, whilst a dome forms a completely closed arch.

The construction of dome-shaped armor with the greatest angle of incidence conceived of, viz., 45 deg. now offers no special difficulties. The inside of the turret is not touched at all by the alteration of the profile, and the superior results obtained in firing out of the 28 cm. chilled cast-iron armor turrets at Pola can thus also be referred to the armor turrets with flat profiles.

When we reflect that the steeper profiled "side" plate of the 30.5 cm. turret fired at on the 22nd of October, 1883, at Buckau, was not breached until it was struck by the fourth shot hitting the Achilles' heel of this construction, that is, the bottom diminution of the profile, we arrive at very favorable conclusions of the resisting powers at chilled cast-iron armor with a flat profile: these conclusions are certainly directly opposite to those of the works at St. Chamond as normal shots to which the French plate was exposed, are impossible with the new armor. Against oblique fire chilled cast-iron armor, however, is capable of resisting in a high degree, so that the conclusion of the St. Chamond Works must in this respect be considered as wrongly drawn.

"The Western Division of the Canadian Pacific Railway." [1*]

BY THE LATE J. C. JAMES AND ALLAN MACDOUGALL, M. INST. C. E., F. R. S. E.

(*Concluded from page* 226.)

TRACK-LAYING.

In a Paper on "The Platelaying of the Jacobabad or Broad-gauge Section of the Kandahar Railway," by Mr. George Moyle,[3] it is stated that sixteen hundred men were employed, twelve hundred for track-laying and four hundred for lifting, lining up, etc.; that the average rate of progress was 1⅜ mile per day; that the greatest length laid in any one day was 2¼ miles; and that the best record for laying 1 mile was two hours. Among the Abstracts[4] a statement is given of the force necessary to lay 1 mile of track per day upon a line in Texas. This is stated to be one hundred and twenty-eight men, exclusive of the force necessary for lifting and finishing the road. The average daily force employed on this railway was two hundred and fifty men, besides one hundred and fifty surfacers, or four hundred in all, against sixteen hundred on the Kandahar Railway, and the rate of progress was nearly twice as great.

Track-laying was begun on the 1st of June, and on the 1st of December 388 miles had been laid on the main line, and 30 miles of side tracks. This had all been laid on the new works west of the town of Brandon, and does not include any of the side tracks put in at the various stations between that town and Winnipeg. The rate of progress was:—

Month.	Working days.	Length.	Rate per day
		Miles.	Miles.
1882 June	26	68.70	2.64
" July	26	63.56	2.44
" August	27	86.86	3.22
" September	26	71.25	2.74
" October	26	59.38	2.28
" November	26	38.30	1.47

The greatest length laid in any one day was 4.10 miles, and on three occasions in August 4 miles per day were laid. The best record was ½ mile in thirty-five minutes. Details of this work are given in the Appendix. The authors regret they are unable to furnish any details of the cost. Meanwhile they can state that it will compare very favorably with those referred to, or with any work of this kind ever executed.

As the track had to be laid so rapidly it would not have been possible to have camps for the track-layers. Instead of this large boarding cars were built in two stories; in the upper the men slept, and in the lower they lived and messed. Each car is capable of affording sleeping accommodation for eighty men. These cars, with the necessary cooking, inspectors, and workshop cars, were the permanent portion of the train, and were always left at the front. The construction train brought up the materials from the nearest side-track; the trains were usually of flat cars, the ties came in loads of three hundred to a car, the rails were laid on the cars, thirty pairs to a car, on which were five boxes of spikes, weighing 112 lbs. each, sixty pairs of fish-plates, and one box of bolts. The ties (no sleepers) were loaded into carts and carted ahead on the dump, distributed, spaced, and lined for a considerable distance ahead of the track-layers. When the rails were unloaded the train was backed up to the furthest point and the rails thrown off the cars in equal lots on each side; the engine then went ahead, and a trolly drawn by horses was run up, on which fifteen pairs of rails, with the necessary fish-plates, bolts and spikes were put. When the trolly reached the last laid rail a pair of rails was dropped, gauged, and the trolly run forward. A gang followed, linking on the fish-plates, and was in turn succeeded by the spikers; the first gang spiked the ends and the center, and the rest followed, spiking each third tie till the whole rail was secured. While this was being done the remaining bolts were put in and the fish-plates fastened securely. By the time the last rail was thrown off the length was completed; a second trolly brought up another load, the first being thrown off the rails to let it pass. By this arrangement the men were never idle, and the work progressed rapidly.

The ties are 8 feet long, 6 inches thick, and average 8 inches on the face; there are two thousand six hundred and forty to the mile. The rails are of steel, flat-bottomed, 56 lbs. to the yard, and 30 feet long; they were rolled in England. The fish-plates are 23 inches long: the ordinary suspended fish-plates weigh 17 lbs. to the pair. In the summer of 1882 an angle-bar was introduced; fish plates of this pattern weigh 34 lbs. per pair. The bolts are 1 lb. and 1¼ lb. each, the heavier ones are used on the angle-bar fish-plates. These make the best joint, as they are notched at each end, which enables the spikes to be driven into two ties, instead of all being driven into one tie directly under the joint.

A train consisted of twenty-one flat cars; it was backed up by the engine; the train had never to go a greater distance for supplies than 8 miles. In ascending, and on the second plateau, two engines were used all the time, in consequence of the grades, as the trains frequently stopped on an ascending grade. Water was readily obtained from the side-ditches and swampy places; no very long runs had to be made. The tenders were filled by means of steam siphons with india-rubber hose attached. It took from twenty-five to thirty minutes to raise 10,000 gallons.[1]

SURFACING.

No ballast was used in 1882. After the rails had been lined and lifted, the ties were packed with the material in the bank, and the berms beyond the ties were taken off, the material being thrown in between the rails to a height of 2 in. above the ties, forming a regular convex surface which sheds the water perfectly. This is known as surfacing. The rails keep a good surface, over which trains travel 25 to 30 miles an hour. One hundred and fifty men were employed on the surfacing, and they kept close to the track-layers all through the season.

TELEGRAPH.

A gang of telegraph operators worked alongside of the track-layers, and every evening the

[1] Additional information, particularly as to the estimated cost of works, is contained in the following reports which will be found in the Library of the Institution:—"Canadian Pacific Railway; Report of Progress on the Explorations and Surveys up to January, 1874," by Sandford Fleming, Engineer-in-Chief. Also "Report on Surveys and Preliminary Operations up to January 1877;" and Reports 1879 and 1880.

[*] From other Selected Papers of the Institution of Civil Engineers.

[3] Minutes of Proceedings Inst. C. E., vol. lxi., p. 289.

[4] *Ibid.*, vol. lxix., p. 445.

[1] Minutes of Proceedings Inst. C. E., vol. lxxi., p. 383

end of the track was connected with headquarters in Winnipeg. About one hundred and fifty men were employed on this work.

SNOW-FENCES.

Fences of Y shape, in lengths of 12 feet, have been put up where considered necessary. These are removable, and will be taken down in summer. Double board-fences, 8 feet high and 12 feet apart, are also to be put up where the experience of the winter's storms may show them to be desirable.

SOUTH-WESTERN AND PEMBINA MOUNTAIN BRANCH.

The work of 1882 also included the construction of a Branch into South-Western Manitoba, 114 miles long, on which the track was laid for its entire length. This branch was opened for traffic on the 12th of December. It was built in the manner already specified.

GENERAL FEATURES.

It is noticeable that all the prairie land is free from stones. For great distances along the line, 1 bushel of stones could not be gathered in 50 miles. In the neighborhood of Brandon the soil is gravelly, and there are some large boulders which are striated in the east and west direction; these are the only boulders to be met with for 400 miles from Winnipeg.

The absence of earth-worms and slugs is a marked feature of this soil. When dry it is hard to work; during the summer it can scarcely be ploughed; when wet it adheres so hard to carriage-wheels and boots, that it can only be removed by being scraped off. A very little moisture produces this state. It is very difficult to work in this condition, as it can scarcely be cast off the shovel or the scraper; with 20 per cent. of moisture it somewhat resembles half-set mastic or glue. The most adhesive qualities of this soil are termed "gumbo". When "gumbo" dries, it bakes too hard to be ploughed; on several occasions it was taken out with picks, in large blocks, and laid by hand in the dump. In its worst condition of moisture, it will hold the hoofs of horses working in it and pull their shoes off; this has occurred repeatedly, and within one hour of their having been set. The authors kiln-dried and soaked some of it, and found it would absorb 72 per cent. of moisture before becoming "slurry."

The frost penetrates the ground to a considerable depth. In the excavations for the main sewer in Winnipeg some years ago, a layer of frozen clay, 12 inches thick, was found 8 feet below the surface in the month of August. The presence of frost in the lower layers of the subsoil is not prejudicial to the growth of the crop. The soil does not heave when the frost leaves it in spring, which is a marked difference to the clay subsoils of the eastern provinces. Houses can be built on sills laid on the surface of the ground; foundation-walls, or piles, have to be carried down 8 feet. Frost has a beneficial effect on the earthworks, crumbling down the "gumbo" and causing it to fall like fine garden soil. It also consolidates the embankments.

As already mentioned, Messrs. Langdon, Shephard, and Co., are the contractors for all the works on the main line. The contractors on the South-Western and Pembina Mountain Branch were Messrs. Preston and McDonald, Scoble and Denison, and John Stewart. Messrs. Ross and Grant laid the track on the branch. All the works have been carried out under the personal superintendence of the late Mr. J. C. James, the Chief Engineer. The construction on the main line was under the charge of Mr. W. D. Barclay, Assistant Chief Engineer, and the whole of the locations under Mr. J. H. E. Secretan. Mr. Alan Macdougall, M. Inst. C. E. was Divisional Engineer, on construction, on the South-Western Branch.

MEMORANDUM BY MR. C. W. VAN HORNE, GENERAL MANAGER OF THE CANADIAN PACIFIC RAILWAY.

In 1883 grading was recommenced at the end of March, and track-laying on the 18th of April; and from that date, until the track reached the end of the Prairie Section, at the crossing of the Bow River, near Calgary, the daily record was as given in Appendix II.

At Calgary the line enters the Bow River Pass, and begins the ascent of the eastern slope of the Rocky Mountains. On the 27th of November the track had reached the summit, 122 miles west of Calgary, and 962 miles from Winnepeg.

The three seasons' work on the Western Division of the main line have been as follows;

	Miles.
1881	165.50
1882	419.86
1883	376.78
	962.15

The sidings, which aggregate 66 miles in length, are not included in any of the figures given.

It will be observed that in seven weeks, ending September 17th, 1882, or in forty-two consecutive working days, 134.88 miles of main track were laid, or an average of 3.21 miles per day, exclusive of sidings. Large as was this average, it was exceeded in 1883, when, for the eight weeks ending August 5th, embracing forty-eight consecutive working days, 166.88 miles of main track were laid, or an average of 3.46 miles per day, exclusive of sidings.

In order to preserve the rails from injury, and to provide a good track over which the enormous quantity of materials and supplies could be moved with certainty and dispatch, the lining and surfacing gangs were kept well up to the track-layers.

It must not be supposed that because the work was so quickly done it must have been poorly done, or that the track was merely stretched out on the surface of the ground. On the contrary, the entire line is thoroughly well built of the best materials, and everything has been done to make it a first-class railway in every respect, and with a view to the greatest economy in operating. The average amount of earthwork from Winnipeg to the foot hills of the Rocky Mountains has been 16,300 cubic yards to the mile. This high average in a prairie country is accounted for by the fact that while, to guard against snow, the grade line is elevated well above the surface of the ground, so as to almost entirely avoid cuttings, long planes and tangents and very low grades have been secured.

With the exception of one short length at the crossing of the Saskatchewan River, the maximum gradients between Winnipeg and a point 4 miles below the summit of the Rocky Mountains, a distance of 958 miles, are 40 feet to the mile, equivalent to 1 in 132.

The steel rails used are all of English and German manufacture; about one-half come from the works of Krüpp, at Essen, in Prussia.

The ties, or sleepers, were brought from the forests about the Lake of the Woods, east of Winnipeg.

The grading of the last 650 miles of the prairie section was done by Messrs. Langdon, Shephard, and Co., who also laid the track from Oak Lake to Calgary. They commenced at Oak Lake in April 1882, and finished at Calgary fifteen months later. In that time, notwithstanding a winter's interruption, they laid 667 miles of main track and 48 miles of sidings, and moved about 10,000,000 cubic yards of earthwork, a feat unequalled in the history of railway construction.

It should be mentioned in this connection, that in order to keep the grading out of the way of the track-layers, the work had to be manned long distances ahead, in some cases nearly 200 miles, and that in a wild country without roads or means of supply, except from the end of the track.

The transportation department was charged with the delivery of all the materials and supplies at the end of the track, and when the quantity of these, and the great distances they had to be transported, are considered, it will be thought no small feat to have moved them to the front day after day and month after month with such regularity that the greatest delay experienced by the track-layers, during two seasons' work, was less than three hours.

Divisional points with train-yards, engine-sheds, coal-sheds, etc., are placed at intervals of 120 miles, and at the alternate divisional points repairing shops are provided. The company owns the telegraph line, which is at all times kept abreast of the track-layers.

During the rapid construction yards were established at intervals of 100 miles, whence all materials and supplies were assorted and forwarded to the front in train lots, each train taking an accurately adjusted lot of rails, ties, fastenings, telegraph material, and other necessary items, so that no material was scattered along the line. The headquarters of the construction department were situated at these material-yards, the offices and houses making quite a village; but all the houses were portable, and of such size as to be readily moved on flat cars, and when, as the track advanced each 100 miles, it became necessary to move on to a new point, the change could be made in a day, and without delay to the work.

During the year 1883 two more branches were built by the company in the north-west, one from Winnipeg to Selkirk, on the west bank of the Red River, 22 miles, and another from Emerson to a connection with the Pembina Mountain branch, 23 miles long.

The whole of the line between Winnipeg and Lake Superior was transferred by the Government to the company in May 1883, and is now in operation, giving the company an independent outlet eastward by way of the Great Lakes during the season of navigation.

The work of the Company for the year 1883 may be summarised as follows:—

	Miles.
Extension of main line, west, from Sturgeon River	100
Extension of main line, east, from Port Arthur	101
Extension of main line, west, to the summit of the Rocky Mountains	376
Algoma branch	96
Ontario and Quebec Railway	200
Selkirk Branch	22
Emerson Branch	23
Making for the year a total of	918

The lines owned and operated by the company at the end of the year were:—

Eastern Division.

	Miles.	Miles.
Main line	445	
Branches	199	
		644

Western Division.

Main line	1495	
Branches	244	
		1,739
Ontario and Quebec Railway		200
Credit Valley Railway and branches		184
Toronto Grey and Bruce Railway and Branches		196
Total		2,963

MEMORANDUM BY MR. JAMES ROSS, GENERAL MANAGER OF THE NORTH AMERICAN RAILWAY CONTRACTING COMPANY.

The North American Railway Contracting Company took a contract to complete the construction of the railway in the end of February, 1883. Mr. James Ross was appointed manager of construction and of all work west of Winnipeg, succeeding the late Mr. J. C. James, whose untimely death occurred on the 27th of February. The company awarded a contract to Messrs. Langdon, Shephard & Co., for the grading, bridging, track-laying, and surfacing from the end of the track to Calgary, a distance of 255 miles; besides the completion of the last season's work from Swift Current, a farther distance of 76 miles, which included building culverts, finishing bridges, dressing up, and surfacing the track. The engineering staff consisting of nine locating parties and fourteen construction parties left Winnipeg early in April. Some of the former travelled more than 500 miles over the prairies in carts,

(*Continued on page 238.*)

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AND

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" " m	2.35	2.50

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Make all drafts, cheques and money orders payable to **Engineering News Publishing Co.**

As a healthy sign of progress among the manufacturers of American pumping machinery, we notice that the well known firm of Henry R. Worthington, of New York, has perfected arrangements for opening a branch house in London. The pumps are to be made at the company's works in Brooklyn, and London only used as a point of sale and distribution in England, on the Continent, and among the Colonies.

ENGINEERING NEWS Three months for One Dollar.

A MOST elaborate and complete working model of Cap. Eads proposed Ship Railway is now to be seen in the building of the Mutual Life Insurance Co., Nassau and Liberty Streets, N. Y. We advise our engineering friends to examine it carefully, whether they favor a canal at sea level, or with locks, or no canal at all, and a route by way of Panama, Tehuantepec or the Nicaragua Lake.

The scheme proposed by Capt. Eads is so novel and radically different from all other plans for crossing the Isthmus that an inspection of an actual working model gives a far better idea of the feasibility of the project than the digestion of pages of printed description or sheets of drawings. The lifting of a 5,000 ton ship from its natural element, and its transport across 134 miles of dry land is a vast undertaking, but the model referred to shows how it can be done and shows it so clearly that little doubt can remain even if we did not have the endorsement of experts who have made the subject a matter of close investigation and study.

The model includes a section of the entrance canal with actual water, the lifting pontoon with its hydraulic jacks and hydraulic governors, the transfer carriage, a model of a 5,000 ton ship, the road bed, and finally the floating turntable for changing directions in the line of route. The whole process of lifting, transfer and final launch again is gone through with, and the engineer can study for himself the manner of distributing the weight on the carriage and the safe support of the ship.

Whether this ship railway ever crosses the Isthmus of Tehuantepec or not is simply a question of capital and human faith in engineering skill; but whether it does or does not, its originators deserve credit for the boldness of conception and the ingenuity displayed in inventing methods for overcoming seemingly impossible difficulties, and in meeting every condition of a new and intricate problem.

We have already in this journal described the route and the method of transfer, so we will not repeat ourselves, but we again advise all who can to see it for themselves.

THE London press indulges in frequent and loud protests against the overcrowding on the Underground Railway, and further and more forcibly still comments upon the foul atmosphere which the passengers are forced to breath.

In the matter of overcrowding, especially during "commission hours," the users of the N. Y. Elevated roads have abundant cause for complaint, but they are more fortunate than their London brothers as regards light and fresh air.

The London *Contract Journal*, in an editorial headed "The Sewer Railway," suggests that a couple of extra cars unprovided with seats be tacked onto the rear of a train during the busy hours so that those who will not wait can stand without incommoding the more fortunate travellers. But as there is a limit to the length of a train and scarcely any to the passengers who insist upon going on the first train they meet, the only benefit we can see arising from this innovation would be the concentration of the crowding. As to the foul air, the same journal advises the use of respirators as the only remedy until new railways are built.

Space is too valuable in the heart of London, where rapid transit is most needed to admit of elevated roads, so the *Contract Journal* falls back upon the old pneumatic method of forcing trains through a tunnel by fans, propelling the cars and driving out foul air by one and the same operation. Although it is admitted that the successful working of such a scheme has yet to be proven, the *Journal* thinks that if a "Pure-air Underground Railway Co." was started, capital, patronage and success would follow.

Newark Improved Sewerage.

Parties interested will find in our "proposal columns" notice of the letting of an important piece of work in the city of Newark, N. J. The undertaking involves the construction of nearly 15,000 lin. ft. of sewer and 11,500 lin. ft. of timber conduit, together with foundations for the pumping plant.

The brick-sewer will be in great part an egg-shaped conduit equivalent to a three foot circular opening, and for about 300 ft. will be a double sewer. The timber flume will be 5 ft. square, built of hemlock lumber, and in marshy ground, founded upon piles; the timber used will be from 4 to 6 in. thick and put together with wooded treenails.

The specification are full and give the quantities of each class of material and work upon which the proposals will be based.

The entire work is to be completed by or before January 1, 1887.

The Aqueduct Bids.

The Aqueduct Commissioners, on Nov. 13, rejected all the bids on Sections A and B, and will readvertise for proposals on the entire line from the City to the Croton Dam.

This action is very unexpected, and will be disappointing and provoking to some of the parties interested. The true cause for so doing is doubtless found in the wide range of the bids of Oct. 29, as seen below, and the impossibility of legally selecting that one most to the interest of the city.

The following table shows the aggregate of each bid of Oct. 29, as based upon the item prices given in our issue of Nov. 1.:—

NAME.	SECTION A.	SECTION B.
Douglass, Dalzell & Douglass,	$1,281,913	$1,348,844.75
Arnold, Gere & Stevens,	1,364,255	1,497,449.
Henry Collins,	970,781.15	1,059,491.35
Hamilton Smith,	1,476,442.50	1,614,945.
Clark & Donovan,	1,009,005	1,103,800.
John Cox & Co.,	1,077,115.03	1,252,411.75
Brown, Howard & Co.,	1,161,175	1,273,700.
Malone, McGrann & Co.,	1,088,012.50	1,187,525.
John B. Devlin,	802,833.56	869,044.63
Swift & McNamee,	1,163,867.50	1,268,405.
Rutter, Rippley & Co.,	1,362,065	1,427,120.
Weber & Wendt,	1,169,000	1,267,770.
John O'Brien,	918,867.80	962,054.20
M. S. Coleman.	1,433,915	1,592,485.
Ward, Mackin & Co.,		1,291,645.

Engineers' Club of Philadelphia.

At the special business meeting of November 1st, the following were elected members of the club:—Bard Wells, Frank A. Hill, R. Meade Bache, Emil Forder, W. E. C. Coxe, Philip Pistor, O. B. Harden, Thos. H. Loomis, Barton Hoopes, Jr., Wm. F. Biddle, Lindley M. Winson, H. W. Sanborn, S. Craige McComb, Wm. H. McCallum, and Wm. H. Wiley.

The Secretary presented, for Mr. A. W. Sheafer, Notes upon the Relative Cost of Haulage in the Anthracite Mines of Penna., by Mules and Locomotives. These embodied results of investigations by Mr. Thos. H. Phillips, Supt. Kalmia Colliery. The results are as follows:--Cost per ton per miles: by locomotive, $\frac{1}{10}$ cent, by mules, 1 $\frac{87}{100}$ cents; saving, per ton per mile by locomotive, 1 $\frac{77}{100}$ cents. This includes operating expenses and depreciation, but does not include the additional number of cars and turnouts and repairs to roads, required for mule service.

Mr. Thomas M. Cleemann continued some previous remarks that he had made on the Strength of Wrought-iron Columns, showing how some recent experiments by Mr. James Christie, at the Pencoyd Iron Works, gave values of the constants in Rankin's formula somewhat different from those generally used, and which would, therefore, be better to adopt for calculating their strength, in structures of American iron.

In discussing the above, Mr. James Christie stated that the experiments referred to by Mr. Cleemann were subsequently supplemented by similar experiments on steel, and a basis established for the relations existing between steel and iron compression members for structures. In addition to the practical results obtained, the experiments were of peculiar interest, inasmuch as they add additional confirmation to the ordinary theory of flexure as propounded by Euler a century ago. Experiments on beams of iron and various grades of steel, show a practically uniform elasticity, however different the material may be in ultimate tenacity. When the lengths of columns are so great in proportion to cross dimensions that failure will occur almost entirely by bending, then the elasticity of the material is the sole measure of its resistance, and the common theory of flexure will apply. The experiments showed that, when certain ratios of length to cross-section were reached, uniform resistance occurred between iron and steel, a fact, he believed, not heretofore known.

Saltpetre Exudation upon Brickwork.

The *American Architect* quoting from the *Chemical Society's Journal* prints an interesting article upon the above subject which we condense as follows:

The unsightly, whitish blotches often seen upon brickwork and even on decorative panels etc., of terra-cotta, are due primarily to soluble alkalies and alkaline earths in the lower grades of clay; to the lime and magnesia in the calcareous pebble deposits present in most clay and also to the lime and magnesia in the mortar used.

The exudation is called by English workmen "Saltpetring," but it is in fact the production of nitre, or saltpetre, as it is often called. This action is not always due to material in the brick but may come from the sand in the mortar; sea-sand, unless washed in fresh water, always produces it.

In a wall faced with pressed brick, the common practice is to "back up" with common brick, uneven and irregular in size, and, as mortar is cheaper than brick, this first is used without stint. When a wall so built becomes thoroughly wetted, either during or after construction, the exudation commences. The tieing of the facing courses of the pressed b ick to the common brick backing also aggregates the evil.

The general action of the materials employed in brick work may be described as follows:—The salts found in the wall coating are sulphates of soda, lime and magnesia; the first present in variable quantities in the clay, and the last two in the clay and in the lime in the mortar, converted into sulphates either in the burning process in the kiln or by absorbing sulphurous vapors from the general atmosphere. The lime in the clay and mortar is in like manner converted into sulphate. These salts are all soluble in water, and as bricks are always wetted preparatory to laying the salts melt, evaporate through the pores of the brick, and effloresce upon the surface.

In 1882, when an unusual outbreak of this nuisance occurred, appearing upon buildings a century old, the cause was investigated by various scientific societies and discussed at length. The substance of their decision was that it was simply ordinary epsom salt or sulphate of magnesia. The action of the sulphurous acid fumes from burning coal combine, with the general moisture and the magnesia in the brick and mortar to form the soluble salt. The present universal use of coal, and the consequent presence of sulphurous vapor now accounts for the appearance of these blotches upon ancient buildings heretofore free from this disfigurement.

If brick clay is taken from the pit after long continued dry weather, the nitrates are found in it in greatest quantity, for it is in such a season that the water of the subsoil is brought to the surface by capillary attraction and the salts held in solution come with it and accumulate at the surface as the water evaporates. Heavy rains wash the nitrates out of the surface and into the subsoil.

Efflorescence commonly occurs when the nitric acid is combined with potassium, hence until this combination occurs no outward sign is given, though the material may be rich in nitrates.

PERSONAL.

M. DE LESSEPS denies the rumor that he is intriguing to obtain the cession of the State of Panama to France. M. DE LESSEPS is to go to Panama in February.

SENOR DON I. CLEMENTE CASTRO, large mine-owner and prominent civil engineer of Chili, has been appointed a special commissioner by the Chilian Government to consult with engineers as to the best manner of mining copper. Address Hoffman House, N. Y,

FREDERICK H. HAMLIN, late Deputy Commissioner of Public Works of New York, died on Nov. 12th of injuries received in a runaway. MR. HAMLIN was born October 19, 1848 in New York; he graduated at the College of the City of New York in 1868, and then studied engineering. In 1870 he was appointed Asst. Engineer in the Department of Public Parks, assisted in the surveys for the Morningside and Riverside Parks, in the construction of the Boulevards and was made Deputy Commissioner of Public Works by Allan Campbell in 1879.

GEORGE W. BIRDSALL, Acting Chief Engineer of the Croton Aqueduct, was, on the 11th, made Chief Engineer by Commissioner THOMPSON, in place of the late ISAAC NEWTON. MR. BIRDSALL is forty-eight years old, and is a New Yorker by birth and education. He has been connected with the Department of Public Works for twelve years, having held the position of Chief Engineer under ALLAN CAMPBELL. When MR. NEWTON was given the office, he made MR. BIRDSALL his First Assistant, a position he has held up to the present time.

FRANCIS COLLINGWOOD, C. E., has returned from a six months' trip abroad. His purpose was to seek the rest and relaxation earned by arduous and long-continued professional services, but with an engineer's instincts he visited many points of interest to the profession in his passage through England, Scotland, France, Germany, Switzerland and Austria, among other new enterprises examining the now famous Ariberg Railway and Tunnel. We learn that MR. COLLINGWOOD has been honored with the Telford Medal, awarded him by the Institution of Civil Engineers, in London, for his interesting paper upon the late Repairs to the Cables of the Allegheny Suspension Bridge.

TRACK.*

BY W. B. PARSONS, JR., C. E.
ROADMASTER SUSQUEHANNA DIVISION ERIE R. R.

(*Continued from page 223.*)

Gravel.—As a rule the most easily and cheaply obtained good ballast is gravel; it should be of medium and uniform coarseness and as free from loam and dirt as possible. It does not give as good drainage as broken stone but still if of good quality water will percolate through it freely. It can be loaded direct from the bank by a steam shovel and unloaded by a plough and cable, thus being handled without much expense. It is easily taken care of by trackmen and can be tamped with a shovel if necessary. When properly filled in and neatly dressed off it gives a very presentable track. The great objection to the gravel is that in dry seasons it is liable to be dusty. If there is much loam with it grass will grow, and in winter it is affected by the frost.

Cinders make a very cheap and excellent ballast; it is porous, does not retain moisture, does not heave much with the action of frost, and can be easily handled with the shovel. In "mud" track in the spring of the year or at wet times when everything is very soft, cinders will often hold up track where even good gravel would fail. They prevent grass from growing and even under heavy traffic will last five years. But their extreme dustiness should forbid their general use for passenger service.

"Mud," improperly called ballast, is the cheapest type of material, being merely the ordinary soil found along the right of way. In summer, if continually dry, it cakes under the action of the sun making work very difficult upon the track. In fair weather a tolerable surface can be maintained, but this is soon destroyed by a few days of rain. In winter the frost causes it to heave very badly, throwing the track out of surface and line and rendering it very difficult to maintain. In spring, when frost leaves it, it becomes very soft, allowing the ties to sink.

When this is the case, as good a remedy as can be applied is to dig out the mud and replace it by a generous bed of cinders. The best method of treatment, however, of mud track is to get rid of it altogether. In any case and at all times efficient drainage is imperative.

Ties.—The question of ties is one that should command, on every road, the closest scrutiny. There is no economy in purchasing timber deficient in either quality or size. Ties are subjected to two deteriorating actions: the natural one of decay; and the cutting into the wood by the rail. To which of these causes the tie will yield first is dependent on local circumstances: viz, nature of ballast, drainage, kind of wood, and amount of traffic.

The action of the first cause is gradual decay until finally the tie ceases to hold the spikes or even support the rail. The action of the second is to have the rail cut and work its way down into the tie under the pressure of the heavy loads over it. This cut forms a receptacle for water, and rot sets in to aid destruction, until the tie has to be taken out as unfit for service, although sound everywhere else in its length. In soft wood ties this latter is almost invariably (always on curves) the cause of failure and frequently so with even the best hard wood ties when subject to the heavy traffic of modern rolling stock. As to size the usually adopted length is probably 8 ft. Unless the ballast is stone where the tie gets full support through its whole length this is hardly enough. The length of 19½ in. outside of gauge side of rail is barely sufficient to afford proper support to the modern style of heavy engine. It is better to have them 8½ ft. or even 9 ft. long. Variation of over 2 in. from the adopted length should not be permitted, first because irregularity in length ruins the appearance of track, and secondly because it gives the track an unequal bearing. As to cross-section, since the length of a spike is commonly 5½ in., of which 5 in. goes into the wood, the tie should not be less than 6 in. thick. This should be rigorously maintained without any variation. When ties vary in thickness they are buried to a different extent in the ballast and therefore unequally affected by moisture, drainage, and frost with consequently serious tendency to injury at the surface. Furthermore in replacing old ties, if the new ones vary in thickness the old bed must be lowered or raised to a different degree

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for each tie. Effect, rough track. Therefore the thickness specification should be strictly enforced. As to width it must be remembered that every wheel strikes a blow to the ties beneath. Nearly all of the later types of engines have 11,000 to 16,000 lbs. on each driver. Therefore on a rail base of 4½ in. and a tie 8 in. wide an engine with 14,000 lbs. on each driver, a strain is produced of nearly 400 lbs. on each square inch of wood surface. When it is considered that this strain is in the shape of a constantly recurring blow, and moreover, that the wood which has to resist it is subjected to exposure and decay, it can be readily seen that a face of 8 in. is none too large. From 8 to 10 in. will be found the most desirable width as presenting a good bearing for the rail; sufficient surface underneath to transmit the weight to the ballast, and as being a convenient size for handling. Ties under size not only are cut into more rapidly by the rail but are likewise driven down into the ballast. Large ties should be avoided as being of old timber, more liable to decay, unweildy to lift and requiring too much "digging" to put into the track. As far as possible ties should be sorted as to size and quality and laid with some degree of similarity; especially should the different varieties of woods be kept by themselves. Track laid in this manner will be found to wear more evenly.

Ties are either hewn or sawed, the latter on two or four sides. Hewn ties are preferable: because they are more lasting to commence with. While this fact is recognized as true it is unexplained; it is probably due to the cutting action of the adze in hewing, which closes the pores of the wood and thus keeps moisture out, while the rough passage of the buzz-saw, on the contrary, leaves these pores all open. Secondly, with the same face a really larger tie is obtained on account of the rounding sides. Thirdly, a very practical reason in favor of hewn ties is that one knows exactly what one gets. It can be seen at a glance whether the wood is old or young and of what quality, while in sawed ties it is possible to pass off wood that is cross-grained, old and even dead, when the already decayed portions have been removed by the saw.

TO BE CONTINUED.

"The Sewering of Towns on the Separate System.—Size and Inclination of Sewers."*

BY ALFRED EDWARD WHITE, ASSOC. M. INST. C. E.

There is no doubt that each of the two systems of sewerage, the separate and the combined, possesses certain advantages and disadvantages, as compared with the other; there being some conditions under which the former system may be adopted with the greater benefit, and other conditions under which the latter is the more applicable. An advantage of some importance, however, which the separate system possesses over the combined system, is that of allowing of the use of sewers of a smaller size.

As a rule the smaller a sewer (within certain limits) the better, provided it is large enough to deliver the maximum quantity required to be disposed of; and the smaller the excess of the maximum flow over the ordinary flow, the more efficient may the sewer be made for the conveyance of the ordinary flow. A sewer constructed to receive the whole of the surface water in addition to the sewage, will not, with the dry-weather flow consisting of sewage only, work as efficiently as a smaller sewer, constructed to convey the sewage with only a limited quantity of surface water. The larger sewer is so much in excess of the requirements of the dry-weather flow, that it will not under ordinary circumstances be self-cleansing to the same extent as the smaller sewer, while the smaller may also be more efficiently flushed with a moderate supply of water.

*From other selected papers of the Institution of Civil Engineers.

It probably is necessary in almost all cases (in order to avoid an unreasonably complicated arrangement of branch drains) to admit the water from back roofs and back yards to the sewers, even where there are separate drains for surface water; but the greater the quantity so admitted the more it will tend to neutralize the advantage above referred to.

To determine the volume of the dry-weather flow in any sewer is a comparatively simple matter, if sewage only be admitted to it, as such volume may be considered equal to the amount of the water-supply; which amount is usually known with sufficient accuracy, and for an average town may be taken at 25 gallons per head per day. In making provision for the maximum dry weather flow of sewage, it is usual to assume that one-half the daily quantity is discharged in from six to eight hours; if therefore the daily quantity be assumed at 25 gallons per head, the maximum flow will be at the rate of 12½ gallons per head in (say) six hours, or about 2 gallons per head per hour.

The amount of rainfall, which it is necessary to provide for in in the sewers, is a much more difficult matter to determine, and one which seems to be often under-estimated. In the first place it is necessary to estimate the amount which the sewers should be capable of receiving above storm-overflows; and in the second place the amount which they should deliver below such overflows. To prepare for the heaviest rains in this country is out of the question, considering the excessive falls which occasionally take place. The rate of rainfall to be provided for above the overflows should be determined with due regard to the degree of risk of such rate being exceeded, and to the amount of inconvenience or damage which would be caused in the event of its being exceeded: but to incur a great expense in constructing large sewers, merely to avoid the probability of their overflowing and causing a a small amount of damage, once or twice in a generation, would be unreasonable. Such expense, however, might be justified where the probability of overflow, and also the damage likely to ensue, were great. With regard to the sewers below storm-overflows, their capacity should be sufficient to avoid overflows of such frequency and amount, as would seriously pollute the watercourses or rivers receiving the overflows.

Under the separate system the only rain which should find its way to the sewers is that falling upon back roofs and back yards, and the quantity may be estimated from the area of such roofs and yards, together with the maximum rate at which rain falls. The above area may be taken at an average of 500 square feet for a house occupied by five persons, or 100 square feet per head of the population, and it may be assumed that the entire rainfall upon such area is discharged into the sewers.

The published rainfall tables, of the description required to determine the maximum rate at which there is a probability of rain falling, are of a very meagre character. Observations of rainfall are not usually taken at shorter intervals than twenty-four hours, and the duration and amount of most heavy rains consequently are not recorded. In the volumes of "British Rainfall,"[1] there are, however, Tables giving all the exceptionally heavy falls reported by observers in various parts of the United Kingdom, and by these Tables some valuable information on the subject is given. Taking the records of the three years, 1880, 1881 and 1882; there are reported fifty-seven falls at a rate of over 1 inch per hour, forty-two over 1¼ inch, thirty over 1½ inch, eighteen over 2 inches, six over 3 inches, and two over 5 inches per hour. The heaviest fall reported was at the rate of 5.80 inches per hour, and it continued for thirty minutes. Regarding these records, the impracticability of providing for the heaviest falls is obvious; it seems to the author, however, that a fall at the rate of 1¼ inch per hour should in average cases be provided for, in sewers which are not relieved by storm overflows, and for the purpose of future calculations it is assumed that such sewers should be capable of receiving a fall of this amount. It should be stated that many of the above-mentioned forty-two falls, which exceeded 1¼ inch per hour, were of such short duration that they would not cause sewers, capable of discharging this amount, to overflow, as the capacity of sewers, independent of their discharging power, is considerable.

[1] "On the distribution of rain over the British Isles." Compiled by G. J. Symons, F. R. S.

The available statistics, of the character necessary to determine the amount of rainfall which it is desirable to provide for in sewers below storm-overflows, are, for the purpose required, of a more satisfactory nature than those above referred to. "British Rainfall" for the year 1880 contains a very useful Table, contributed by Mr. Baldwin Latham, M. Inst. C. E., prepared from the records of a self-recording rain-gauge at Croydon; such Table giving the quantity, duration, and rate per twenty-four hours, of all falls of rain of any importance, from March 1879 to April 1881. Some similar information is afforded by the records of a self-recording rain-gauge at Camden Square, London, which have very kindly been placed at the disposal of the author by Mr Symons. As these records have not before been tabulated, a Table prepared from them, giving particulars of the important falls of 1881 and 1882, is appended to this Paper.

Table 1, which is an abstract from the above-mentioned Tables, shows the number of times certain rates of rainfall were exceeded in two years; also the aggregate duration of the falls exceeding these rates.

TABLE 1.

—	Rate of Fall in fractions of an in. per hour.	Number of times rate was exceeded in two years.	Aggregate duration of excessive falls in hours.
Croydon Records	¼	38	20½
	½	78	45
	¾	108	73
	1	154	115½
Camden Square Records	¼	59	11½
	½	99	35½
	¾	136	71½
	1	202	119

From this Table may be obtained, approximately, the number of times that storm-overflows would come into action with sewers capable of discharging various amounts of rain, and also the aggregate duration of the overflows. As, however, a number of the falls included were of very short duration, and in many cases would not be simultaneous over the whole drainage area, it may be assumed that some of them would not cause overflows, and that the duration of the overflows caused by others would be reduced; and to compensate for this a deduction of (say) 20 per cent., should be made from the figures in Table 1. Now, taking a sewer capable of discharging a rainfall of ½ inch per hour, and making the required deduction, the number of overflows during two years, according to the Croydon records, would be eighty-six, and according to the Camden Square records one hundred and nine, and their aggregate duration, in each case, about fifty-eight hours: or during one year the number of overflows would be forty-three and fifty-four and a half respectively, and their duration, in each case, about twenty-nine hours. Overflows to this extent in most cases, and probably to a considerably greater extent in many cases, would be admissible, and for the purpose of future calculations it is therefore assumed that sewers below storm-overflows should be capable of discharging ½ inch of rainfall per hour.

It is of interest to notice that of the rainfalls at Croydon and Camden Square, during the

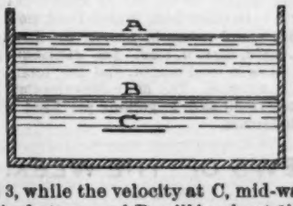
above period, none amounted to the maximum quantity which would be received by sewers capable of discharging 1¼ inch per hour. Eight falls were in excess of one-half the capacity of such sewers, forty-six of one-quarter, and one hundred and sixty-eight in excess of one-eighth their capacity. The heaviest fall, which was at Camden Square, continued for ten minutes at the rate of 1.68 inch per hour; this, however, taking into consideration the shortness of its duration, was about 12 per cent., below that which sewers capable of discharging 1¼ inch per hour would receive. The fall second in importance was at Croydon, and continued for ten minutes at the rate of 1.34 inch per hour, this being about 30 per cent., below the amount the sewers would receive.

Upon the area before mentioned as that which may be assumed to be covered, per head of the population, by back roofs and yards, viz., 100 square feet, a rainfall of 1¼ inch would produce 65 gallons; and as the maximum volume of the sewage proper, in average cases, as already determined, is about 2 gallons per head per hour, a total of 67 gallons per hour, should be provided for in sewers which are not relieved by storm-overflows. With regard to sewers below storm over-flows, the volume to be provided for, per head per hour, according to the foregone conclusions, is a rainfall of ¼ inch on 100 superficial feet, or 6½ gallons, and 2 gallons of sewage, making 8½ gallons.

Sewers should, where possible, be constructed with such inclinations as will render them self-cleansing with the ordinary flow of sewage; and where this is impracticable, the inclination should at least be sufficient to give a self-cleansing velocity with the assistance of flushing.

As to the velocity necessary for self-cleansing purposes, authorities differ somewhat. It seems to be usually considered that small sewers require a greater mean velocity of sewage flow than large sewers, but the grounds upon which this assumption is based do not seem very clear. The bottom velocity is that upon which the self-cleansing properties depend; but how is this velocity to be determined? The size, form, gradient, and depth of flow of a sewer being given, there are several reliable formulas for calculating the mean velocity, but not so the bottom velocity. One authority states the bottom, mean, and surface velocities to be nearly as 3, 4, and 5, and others express the ratio by figures nearly corresponding with these. It appears to be assumed that these proportions apply under all circumstances; but that this is a mistaken assumption, the author would submit, may be proved as follows:—

If a trough be taken, as shown by the annexed diagram, in which the water is up to A, then, according to the above rule, if the velocity of flow at A be represented by 5, that at B, half-way down, will be about 4, and at the



bottom 3, while the velocity at C, mid-way between the bottom and B, will be about 3½. Now if the water be only up to B—that is to say, of half the depth before assumed—and the inclination be increased so that the mean velocity is the same as before, then the velocity at C, it being about the mean, will be 4. Thus in the former case the velocity at C, which was 3½, was less than in the latter, the mean velocity in each case being the same. How then will the bottom velocities in the two cases correspond? The velocity of the bottom-water is affected by three forces: 1. Its own gravity, due to the inclination of the trough. 2. The velocity of the water directly above. 3. Its friction upon the bottom of the trough. The first force, that of gravity, is greater in the latter case, or with the shallow flow, as the inclination is greater; the second force, that of the water above, is also greater in the latter case, for, taking any point above the bottom, as for instance the point C, the velocity at that point is greater in the shallow flow. The third force, that of friction, upon the bottom of the trough, is equal in each case. Both the force of gravity, and the greater velocity of the water above, tend to give the bottom-water a greater velocity with the shallow flow, and it is therefore evident that the difference between the mean and the bottom velocity is greater with a deep flow of sewage than with a shallow flow, or, under ordinary circumstances, with a large sewer than with a small one. It would therefore appear that the mean velocity necessary to render sewers self-cleansing is greater with a deep flow than with a shallow flow.

It may be assumed that 150 feet per minute is an ample self-cleansing velocity for ordinary sewers when running half-full or thereabouts, and 135 feet per minute is probably quite sufficient for a shallow flow, such as that discharged in dry weather, provided the sewage be sufficiently deep to float or submerge the solid matters contained in it.

The inclinations necessary to produce a velocity of 150 feet per minute in circular sewers of various sizes, flowing half-full, or full, and in egg-shaped sewers flowing two-thirds their vertical height, are shown in Table 2; also the population which such sewers, when running full, would be capable of serving at 67 gallons per head per hour above storm-overflows, and 8½ gallons below storm-overflows.

Sewers should be constructed to flatter inclinations than the above, and these inclinations are only admissible where flushing power is provided.

In the preparation of the foregoing and following Tables, the formulas used are those of Eytelwein, viz:

$$V = 5604 \sqrt{RS}.$$

$$S = \frac{V^2}{R\,(5604)^2}.$$

where V = velocity in feet per minute.
S = sine of inclination.
R = hydraulic radius.

To ascertain the gradients required for self-cleansing with the dry-weather flow, it is necessary to determine the amount of such flow as compared with the capacity of the sewers. According to the figures already given, the maximum quantity to be provided for in sewers above storm-overflows is 33½ times, and in sewers below storm-overflows 4½ times, the maximum dry-weather flow. The difference, however, between the dry-weather flow and the capacity of the sewers would often be considerably greater than this, as sewers are of necessity somewhat larger than necessary for the maximum flow, through certain portions of their length, especially on approaching dead ends. To allow the required margin, let it be assumed that the capacity of sewers above storm-overflows is 45 times, and below storm-overflows 5 times, the maximum dry-weather flow. Working upon these proportions, the inclinations required above storm-overflows in sewers of various sizes, to produce a velocity of 135 feet per minute with the dry-weather flow, are shown by Table 3; also the depth of the dry-weather flow, the assumed population contributing to it, the velocity when running full, and the population which the sewers, when running full, would be capable of serving, at 67 gallons per head per hour.

Table 4 gives particulars, similar to those in the preceding Table, with reference to sewers below storm-overflows, the maximum flow being taken at 8½ gallons per head per hour.

The difference shown in Tables 3 and 4 between the population contributing to the dry-weather flow, and the population which the sewers are capable of serving, represents the margin allowed in determining the amount of the dry-weather flow, as compared with the maximum flow, as previously explained. Should the population contributing to the dry-weather flow be less than that stated, in which case the volume of sewage would also be less, an increased inclination would be required to give the self-cleansing velocity.

The size of sewer for inclinations other than those in the Tables may easily be calculated from those given, the discharge being in proportion to the square root of the sine of the inclination. The size, however, for a given population and given inclination, may vary considerably, according to the local conditions affecting the volume of sewage per head to be disposed of.

With sewers on the combined system, the maximum amount of water to be dealt with, in proportion to the population, would probably be, in an average case, three times that provided for in the Tables; and the population served by a sewer of a given size would consequently be proportionately less.

TABLE 2.

Size of Sewer.	Inclination to produce velocity of 150 feet per minute.	Population served by sewers above storm-overflows.	Population served by sewers below storm-overflows.
Ft. Ins. × Ft. In.			
0 6 × 0 6	1 in 174	165	1,297
0 9 × 0 9	" 261	376	2,919
1 0 × 1 0	" 349	654	5,189
1 3 × 1 3	" 436	1,028	8,107
1 6 × 1 6	" 524	1,481	11,675
2 3 × 1 6	" 661	2,080	16,390
2 6 × 1 8	" 784	2,567	20,235
2 9 × 1 10	" 908	3,106	24,485
3 0 × 2 0	" 882	3,697	29,140
3 3 × 2 2	" 955	4,340	34,200

TABLE 3.

Size of Sewer	Inclination to produce velocity of 135 feet per minute, with maximum dry-weather flow.	Depth of dry-weather flow, or of flow equal to one forty-fifth the capacity of sewer.	Population contributing to dry-weather flow.	Velocity when running full in feet per minute.	Population served by sewer when running full at 67 gallons per head per hour.
Ft. Ins. Ft. Ins.		Inch.			
0 6 × 0 6	1 in 70	0.56	230	180	308
0 9 × 0 9	" 75	0.83	514	"	691
1 0 × 1 0	" 100	1.11	915	"	1,229
1 3 × 1 3	" 125	1.39	1,428	"	1,919
1 6 × 1 6	" 150	1.67	2,037	"	2,764
2 3 × 1 6	" 214	2.63	2,708	252	3,638
2 6 × 1 8	" 238	2.92	3,343	"	4,491
2 9 × 1 10	" 262	3.21	4,046	"	5,435
3 0 × 2 0	" 286	3.50	4,816	"	6,468
3 3 × 2 2	" 310	3.79	5,650	"	7,590

TABLE 4.

Size of Sewer.	Inclination to produce velocity of 135 feet per minute, with maximum dry weather flow.	Depth of dry weather flow, or of flow equal to one-fifth the capacity of sewer.	Population contributing to dry weather flow.	Velocity when running full in feet per minute.	Population served by sewer when running full at 8½ gallons per head per hour.
Ft. Ins. Ft. Ins.		Inch.			
0 6 × 0 6	1 in 145	1.76	1,213	165	1,427
0 9 × 0 9	" 217	2.64	2,729	"	3,211
1 0 × 1 0	" 289	3.52	4,852	"	5,708
1 3 × 1 3	" 361	4.40	7,581	"	8,919
1 6 × 1 6	" 434	5.28	10,917	"	12,843
2 3 × 1 6	" 525	8.79	15,577	161	18,326
2 6 × 1 8	" 583	9.77	19,231	"	22,625
2 9 × 1 10	" 642	10.75	23,270	"	27,377
3 0 × 2 0	" 700	11.72	27,693	"	32,580
3 3 × 2 2	" 758	12.70	32,502	"	38,237

(*Concluded from page 233.*)

and over the mountains on pack-horses, before they reached the scene of their operations. Surveys in the Selkirk Range were not commenced until the 10th of July. A special system was organized for keeping the general manager of construction informed of what was going on in the immense district under his charge, and especially for communicating with locating parties. This was the perfecting and extension of last year's courier mail service.

The Railway Company determined to reduce the grades from the top of the west bank of the River Saskatchewan to a point near the summit of the Rocky Mountains, to 40 feet per mile instead of the maximum grade of 52.80 feet per mile used in 1882. At the same time they wished the track to reach the summit of the mountains in the current season. On the located line of 1882 the most suitable gradient had been applied, involving very heavy mountain-work and a tunnel ½ mile long. No information was available as to other parts of the country, and Mr. Ross and many of his staff had never been so far West before. Shortly after the engineering parties had left the end of the track, 555 miles west of Winnipeg, the courier service was organised to run a distance of 280 miles, extending the service westwards as the track-laying advanced. Each courier was equipped with a pony-saddle and mail-bag. One man was assigned to every 40 miles; the time allowed to cover this distance was eight hours; and at each station a fresh courier was ready to continue the journey. By this arrangement the entire distance of 280 miles was covered in three and a half days.

The engineering camps were 13½ miles apart, every camp was numbered, and each division lettered. A system of way-bills was established, by which any lost letters could be traced, similar to that adopted by railway companies to trace lost freight. The benefits arising from this were inestimable, changes in location were perfected, construction pushed on, no delays were incurred, and the staff at head-quarters were always fully informed of all that was going on. As an example, two locating parties were sent to change the line between the River Saskatchewan and Calgary for a distance of 181 miles; one party went ahead to determine the practicability of the route, for the grade of 40 feet to the mile, and the second party to locate the permanent line. Though these two parties started from a point 74 miles west from the end of the track, had three weeks' start of the graders, and were able to locate 4 to 5 miles a day, yet the graders were many times in sight of their back picket-man. The same can be said of the work west of Calgary, with the exception that the location was slower, more preliminary surveys having been required.

The organization required for supplying the men and teams was much the same as that already referred to in the account of the previous season's work. Different plant was required west of Calgary, and the difficulties were much increased owing to the great distance from the base of supplies, the summit in the mountains being 963 miles from Winnipeg. The number of men and horses to be fed made this a question of continual anxiety. The greatest number of men employed was five thousand, and nineteen hundred teams; the cost of feeding them was $100,000 (roundly £20,000) per month.

From the end of the track to Calgary the character of the work was similar to that of the previous year. Messrs. Langdon, Shephard & Co., completed their contract on the 15th of August, the day specified by their contract. From Calgary westwards the line is being constructed by the North American Railway Contracting Company.

Calgary is at the eastern base of the foot hills of the Rocky Mountains, the mountains proper begin at "the Gap" 56 miles farther west. The summit of the mountains, the objective point of this season's operations, is 67 miles west of "the Gap," or 123 miles west of Calgary. The line follows the Bow River for nearly the entire distance, and in order to retain the grade of 40 feet per mile, several heavy cuttings and embankments had to be undertaken. For some miles the average earth and rock work was 70,000 cubic yards per mile, besides a large amount of bridging.

Taking into consideration the class of the work, heavy rock, cemented gravel, and hard-pan cuttings, some of them containing 50,900 cubic yards, and the amount of bridging intervening, the rapidity of work on this section will equal that on the prairies.

A length of 123 miles was completed in eighty days.

The amount of earthwork and rock shifted each month during the season 1883, east of the summit, was—

	Cubic Yards.
April	47,187
May	1,357,398
June	1,261,878
July	1,104,685
August	895,474
September	488,421
October	331,526
Total	5,486,569

Besides the grading, bridging, and track-laying, the Contracting Co., finished all buildings, wells, tanks, telegraph lines, etc., and handed over to the Railway Company a completed railway ready for operation.

The large bridge over the River Saskatchewan is under construction. It is 1,000 feet long, is 45 feet above the river-bed to the rails, and consists of three spans of 217 feet each, two spans of 30 feet each, and a draw-span of 300 feet. The piers and abutments are of limestone from the quarries near Winnipeg. The material for a temporary bridge, which was put up, was freighted along the prairie from the end of the track, a distance of 66 miles.

On the section between Calgary and the summit there is a length of 2 miles and 3,000 feet of bridging, which includes eight crossings of the Bow River averaging from 400 to 800 feet each; one crossing of the Kananaskis, three crossings of Devil's Head Creek, and one trestle work 250 feet long by 80 feet in height. The rapidity of these streams made the construction of temporary bridges slow and difficult.

Three large division-yards for storing materials, with sidings, round-houses, coal-sheds, water-supply, etc., have been constructed, as well as twenty double-section men's houses, and twenty water-tanks and water-supply stations.

Between the River Saskatchewan and Calgary water for the engines is more difficult to obtain than on any other section of the line owing to the character of the sub-strata. Two large well-boring machines, with outfits, were prepared and used continuously night and day. Tubing has been sunk to the depth of 2,000 feet in some places with satisfactory results in obtaining water.

Track-laying commenced on the 18th of April; very little grading was done in that month. The best day's track-laying was made on the 7th of July, when 6 miles and 100 feet of main line, and 1,800 feet of side-track were laid. All the track was full-spiked, bolted, and tied (sleepered.)

APPENDIX.

I.—DETAILED STATEMENT SHOWING DAILY PROGRESS OF TRACK-LAYING FOR 1882.[1]

Day of the Month.	June.	July.	Aug.	Sept	Oct.	Nov.	Dec.
	Miles.	Miles.	Miles.	Miles.	Miles.	Miles.	Miles.
1		2.80	3.86	3.35	S.	2.55	2.05
2		S.	3.60	3.54	0.68	2.55	1.00
3		2.10	4.00	S.	1.80	2.75	0.51
4		2.24	3.50	3.37	0.68	1.10	2.01
5		2.10	3.30	2.30	..	S.	..
6		1.62	S.	2.30	2.14	2.70	..
7		2.10	3.10	3.17	2.56	1.10	..
8		3.47	3.00	3.75	S.	2.00	1.86
9	53.20	S.	2.90	3.17	2.90	0.90	1.06
10		..	2.60	S.	2.75	..	S.
11		1.80	2.54	3.50	2.75	..	..
12		2.17	2.90	3.26	2.56	S.	0.80
13		2.00	S.	3.00	1.60	0.50	..
14		2.00	3.35	3.05	2.75	1.50	0.28
15		2.62	3.10	3.36	S.	2.10	0.51
16		S.	2.75	3.30	3.00	0.80	0.44
17		2.30	3.00	S.	1.75	1.00	0.57
18		3.07	1.60	3.55	3.66	2.00	1.12
19	2.42	2.74	4.10	2.30	2.75	S.	1.78
20	2.00	1.90	S.	1.60	2.95	2.10	1.50
21	1.12	3.07	3.36	..	2.55	2.00	1.52
22	.65	2.35	2.95	2.60	S.	1.90	1.70
23	.52	S.	2.95	2.30	2.80	1.90	1.44
24	..	3.16	3.26	S.	2.85	2.00	1.00
25	S.	3.16	3.54	2.40	2.75	1.75	1.14
26	1.65	2.00	3.00	2.23	3.10	S.	1.74
27	0.82	3.23	S.	2.50	2.55	0.50	1.52
28	2.06	3.06	3.50	2.75	1.25	..	1.31
29	1.26	3.00	4.05	2.50	S.	0.00	1.08
30	2.00	S.	3.50	2.00	2.75	2.00	1.66
31	..	3.50	3.55	..	2.50	..	S.
..	68.70	63.56	86.86	71.25	59.38	38.50	30.30

[1] The statement for December 1882 and January 1883 has been supplied by Mr. C. Van Horne; and that for April to November 1883 by Mr. James Ross.

In addition to the foregoing, 1.95 mile of main track was laid on the 1st, 2nd, and 3rd of January, 1883, when heavy snow storms brought the season's work to an end, the grading having been stopped by frost on the 13th of November.

II.—DETAILED STATEMENT SHOWING DAILY PROGRESS OF TRACK-LAYING FOR 1883.

1883	Apr.	May.	June	July	Aug.	Sept.	Oct.	Nov.
	Miles.	Miles.	Miles.	Miles.	Miles.	Miles.	Miles.	Miles.
1	..	1 17	..	S.	3 09	1 78	2 03	1 40
2	..	..	..	2 78	3 28	S.	2 58	1 78
3	..	..	S.	4 68	3 31	1 93	2 21	1 74
4	..	..	..	3 63	3 24	1 80	1 00	S.
5	..	2 16	..	3 63	S.	1 70	..	1 60
6	..	S.	..	3 90	3 30	..	..	1 52
7	..	2 50	1 64	6 02	2 93	..	S. 1 78	2 21
8	..	2 50	2 63	S.	1 70	0 78	1 06	2 14
9	..	1 60	1 60	3 90	..	S. 0 86	1 02	1 17
10	..	2 58	S.	3 79	..	1 46	2 15	2 20
11	..	2 06	3 22	3 07	3 09	1 78	1 42	S.
12	..	2 84	3 50	3 75	S.	1 62	2 05	2 37
13	..	S.	3 35	3 67	..	1 44	1 60	2 12
14	..	2 63	3 79	4 34	0 37	1 87	S.	1 29
15	..	2 96	3 24	S.	1 57	1 34	1 67	2 01
16	..	2 78	3 24	2 91	0 81	S.	2 05	2 08
17	..	2 31	S.	3 77	..	2 14	0 81	1 52
18	0 51	2 87	3 07	1 17	..	1 76	0 70	S. 1 50
19	1 36	3 13	3 79	..	S.	2 24	2 10	0 66
20	1 31	S.	4 00	3 24	..	1 52	2 08	..
21	1 69	3 09	2 91	4 11	1 00	2 14	S.	0 64
22	S.	3 07	3 70	S.	1 60	2 34	2 18	..
23	1 57	3 20	3 67	3 60	0 68	S.	1 36	..
24	2 10	3 01	S.	3 71	..	1 50	1 67	..
25	2 16	0 65	3 60	2 50	..	..	1 78	..
26	1 57	..	3 45	3 86	S.	..	1 68	..
27	1 10	S.	3 33	2 88	..	..	1 70	..
28	1 06	2 95	3 48	6 38	..	..	S. 1 36	..
29	S.	1 91	2 61	S.	1 21	..	1 67	..
30	2 14	..	3 13	3 66	1 27	S.	1 69	..
31	..	..	..	3 40	1 68	..	0 25	..
..	17 57	51 97	66 95	92 35	41 23	32 00	43 65	26 87
Side-tracks	1 05	2 15	5 47	5 11	4 55	1 40	2 48	3 08
..	18 62	54 12	72 42	97 46	45 78	33 40	46 13	29 95

WATER.

AN artesian well at Salamanca, N. Y., was bored through 114 feet of limestone rock and now flows at the rate of 25,000 barrels in 24 hours.

LIMA, Ohio, on the 4th inst. appropriated $700,000 for the construction of water-works, E. F. Davis is City Clerk, and Jno. P. Haller is City Engineer.

ACCORDING to the *Japan Mail*, it is believed that the Yokohama Water-works will be started next spring. The works are to cost about $1,000,000, and financial reasons have delayed the project so far.

THE New Liverpool Water-works have cost during the past three months as follows: The Llanwddyn embankment, 20,158*l.*, or a total of 246 853*l.*; the quarry cost 9,281*l.* in the same period, or a total of 84,327*l.*; the aqueduct 32,178*l.*, or a total of 519,957*l.*; and the land and easements 551*l.*, or a total of 230,560*l.*, making a grand total of 1,081,700*l.* 19*s.* 7*d.*

REFERRING to the failure of the Water-works at Sioux Falls, Dakota, mentioned in this column last week as "Holly Water Works" we are informed by the Holly Manufacturing Co., of Lockport, N. Y., that they have no knowledge of any such works being built and that therefore they are not genuine "Holly Water Works at all.

H. A. HANCOX, C. E. has made a report upon the proposed water supply of the city of Ellsworth, Maine. The water is to be taken from Branch Pond, 210 ft. above the city datum, and enters by gravity the distribution by a 12 in. main, 25,080 ft. long. The distribution system is 7.37 miles in total length, and the total cost is estimated at $87,989.66. The daily consumption is put down at 260,000 gallons or 52 gallons per head per day for 5000 inhabitants.

NEWS OF THE WEEK.

Railroads and Canals.

CITIZENS of Brooklyn, Long Island, object to the proposed cable railway on Bedford Ave.

THE survey for the narrow gauge railroad between Chester and Media is nearly finished.

Malloy & Mears on Monday last completed their contract of grading section No. 24 of the new Baltimore and Ohio Railroad in Delaware.

STEEL rails are being laid on the Dayton and Ironton branch of the Toledo, Cincinnati and St. Louis Road at the rate of a mile a day.

JAPAN is so pleased with the great success of the railways already built that Yokohama advices state that several new Companies are forming.

THERE are but three railroads in this country that have retained their original names for thirty years; these are the Pennsylvania, the Michigan Central and the Baltimore and Ohio.

THE Chicago, Burlington and Quincy Co. are surveying a new line between Council Bluffs and Pacific Junction, Neb., the intention being to remove the track from its present line beside a stretch of swamp lands on the other side of the river.

A WROUGHT iron viaduct nearly seventy feet high is being erected in place of the trestle in Marlboro, N. H., on the Manchester and Keene Railroad. The Boston and Lowell, which now runs this road, is expending money freely to put it in prime condition.

ON the 26th of June the U. S. Interior Department authorized a preliminary survey of an extension of the Milwaukee, Lake Shore & Western from the Montreal River between Wisconsin and Michigan to Ashland, Wis. The survey was begun but had not been completed. As the line ran through an Indian Reservation, the survey was made subject to the consent of the Indians. This being granted construction will now be undertaken under a bond of $20,000, to indemnify them for right of way.

PORTLAND, Oregon, Nov. 12.—London advices state that the Oregon Construction Company has been awarded the contract for building, equipping, and keeping in repair for one year a railroad from the present terminus of the Oregon and California road, to meet the California and Oregon road at the State line. The contract price is $2,000,000. It is not known when work will be begun, and it is not unlikely that the action of the Construction Company will depend on the course of the Central Pacific in extending their Oregon Branch to the State line.

PRESIDENT CALLERY, of the Pittsburg and Western Railroad, says that the final contract conveying to the Seaboard and Western Railroad Company a running right over the Pittsburgh and Western tracks, from Sharpsburg to Smoky Island, where the Pittsburgh and Western has sold to the new company six acres of land, has been signed by both parties and the money paid over. This is a sure indication to railroad men that this line will be built. The Pittsburgh and Western will connect with the Lehigh Valley Road, with which it will work in harmony, but as previously stated the Lehigh Valley is not in any sense backing the enterprise.

Miscellaneous.

BROOKLYN is going to try the experiment of dumping its garbage and street refuse into the sea.

THE directors of *La France*, a Paris newspaper, have determined to organize and send out an expedition to investigate the conflicting reports concerning the Panama Canal.

THE following is an abstract of the proposals for 20,000 cubic yards of dredging on Moose-a-bec Bar, Maine, opened by Colonel C. E. Blunt:

Moore & Wright, of Portland, Me., were the only bidders. The price asked by them was 48c. per cubic yard. This was the same price bid by them in August, when the bids were rejected. This work will be done next May or June, and will then be advertised.

CHIEF ENGINEER CHAS. H. LORING in his annual report to the Secretary of the Navy, asks for the fiscal year ending June 30, 1886, $1,000,000 for steam machinery; $17,317 for the civil establishment of the navy; $2,521,000 for the increase of the navy; $65,000 for the completion of the machinery of the New York, and $206,000 for the engines, etc., of the monitor Monadnock. The navy increase includes one 4,500 cruiser, one 3,100 cruiser, one 1,500 ton dispatch boat, two heavily armed 1,500 ton gun-boats and one light gun-boat of 900 tons and one of 750 tons, one steel ram, one cruising torpedo boat, two harbor torpedo boats and one armored vessel of 8,500 tons.

THE following is an abstract of the proposals opened by General Wm. Smith, U. S. Agent, for dredging in Corsica Creek, Md.:

American Dredging Co., Philadelphia, Pa., 20c. per cubic yard in scows and 26c. in place.

Morris & Cummings Dredging Co., New York city, 25c. per cubid yard.

Thomas P. Morgan, Washington, D. C., 14c. per cubic yard.

P. Sanford Ross, Jersey City, 16c. per cubic yard in scows and 18c. on site.

Frank C. Somers, Philadelphia, 13 9-10c. per cubic yard measured in scows.

Baltimore Dredging Co., Baltimore, 15½c. per cubic yard in place and 13c. in scows.

The contract has been awarded to Thomas P. Morgan.

PROFESSOR ROBINSON of Columbus, Ohio, is giving his attention to the matter of bridge vibrations, having contrived an automatic register for recording the same.

SEALED proposals for building a house for the fire department on Old Slip between Front and Water streets New York, until November 19. For further particulars see City Record of November 10, and following.

THE construction of the first street cable-tramway in Scotland is just about to be begun on the north side of Edinburg, where the gradients are very steep. The continuous wire cable will be about six miles in length.

THE bids of Paradise & Young, of Memphis, Tenn., for joiner work of white pine and cherry at $26,944, and for wood flooring at $2,555, for the custom house, etc., at Memphis, Tenn., have been accepted.

THE King Iron & Bridge Company is to have the contract for furnishing the iron work for the Kingsbury Run Viaduct at Cleveland, Ohio.

PROPOSALS are advertised by the Department of Public Parks of this city for grading, curbing, flagging and building sewers in Harlem. Bids will be received until 10, A. M. November 25th. For further particulars, see City Record.

No proposals were received by Colonel Merrill for removing the wreck of the model barge Potomac from the Ohio River, above Pomeroy. He will be authorized to remove the wreck himself.

A COMPANY under the name of the Mitchell, West Baden & French Lick Railroad Company, has been incorporated in Indiana to build a road from Mitchell, Lawrence County, to West Baden and French Lick, Springs, Orange County, a distance of 20 miles. George F. Montgomery of Vincennes, Ind., is the principal stockholder.

Popular Science Monthly claims that an Italian ship has been sheathed with glass plates, cast like iron, so as to fit the hull, to take the place of copper sheathings. A waterproof mastic is used for jointing the plates. The advantages claimed for the new material are insensibility to oxidation, and exemption from incrustation.

CHARLESTON, S. C., invites proposals for sinking an artesian-well, the depth to be not less than 2,000 feet, with a minimum diameter of six inches at the maximum depth. All proposals must be forwarded to Zimmerman Davis, Secretary and Treasurer of the Charleston Water-Works Company, by December 15 next.

The following bids were opened October 28, 1884, by Colonel Elliott, for furnishing rip-rap granite for the breakwater at Block Island, R. I. The prices are per ton of 2,240 pounds:

James Scully, Groton, Conn., $1.65.

Isaac A. Sylvester, Newton Center, Mass., $1.67.

Contract awarded to James Scully.

The following is an abstract of the proposals for dredging in Lubec Channel, Maine, opened by Colonel C. E. Blunt, Corps of Engineers, U. S. Army:

Moore & Wright, Portland, Me., 42c. per cubic yard for 32,000 cubic yards. The contract was awarded to Moore & Wright, who were the only bidders.

THE prevalent idea that the temperature of the earth increases with the depth of descent is by no means correct. One of the most decided exceptions to the general law in this respect is that exhibited by the New Almaden, Cal., quicksilver mine, in which, at a depth of about 600 feet, the temperature has been noted at 115 degrees, but in the deepest part of the same mine, 1800 feet below the surface and 500 feet below sea level, the temperature is very pleasant, say less than 80 degrees. At the Eureka mines, in California, the air 1200 feet below the surface appears nearly as cool as at 100 feet below. The mines on the Comstock vein, Nevada, are exceptionally hot, so that at depths of 1500 to 2000 feet, the thermometer placed in a fresh drilled hole will show 130 degrees: very large bodies of water have run for years at 155 degrees, and smaller bodies at 170, the temperature of the air being kept down to 110 degrees, by forcing in fresh air cooled over ice. The heat extracted annually from the Comstock, by means of the water pumped out and cold air forced in, has been estimated as equal to that generated by the combustion of 55,560 tons of anthracite coal or 97,700 cords of wood.

CHEYENNE, W. T., November 1.—A large party of Burlington and Missouri surveyors have been employed to the north of Cheyenne for some time past. The party started some time ago from Brush Station, on the line of the Burlington route in Colorado, and are now at a point in Wyoming known as Chug Springs, and will survey the most feasible routes for a railway from the neighborhood of the Chug-water in a northwesterly direction.

WORKMEN at the Brooklyn Navy Yard are now engaged upon the iron masts for the new steel cruisers. They weigh less than the wooden spars which they are to replace. The frame consists of three T irons set in circular wooden plates. To the head of these irons are riveted plates, 12 feet long and ⅜ inch thick, rolled into the required shape. The mainmast is 68 feet 4½ inches in length. Iron masts suffer but little from cannon shot and will not splinter.

MR. WM. BARNET LE VAN is authority for the statement that the quickest time ever made between Philadelphia and Jersey City was made by locomotive "5000," the five thousandth built by the Baldwin Locomotive Works, on May 14, 1880, over the Bound Brook route.

Distance	89.4 miles.
Time	98 minutes.

The weight of the train complete was 148 tons. The return trip was made in 100 minutes.

CHILI is traversed by over 1,100 miles of road completed. And nearly as much more is projected. The principal roads in operation are as follows: Santiago & Southern, 446 miles, and Valparaiso & Santiago, 144 miles, both owned by the government, with headquarters at Valparaiso; Copiopo railway, 152 miles—English owners—headquarters Caldera, Chili; Carrizal & Cerro Blanco railway—owned in England—headquarters Carrizal, Chili; and the Coquimbo railway, Enrique A. Vivian, superintendent and engineer, Valparaiso Chili.

THE following is an abstract of the proposals for removal of wreck of ship Parfield, off Little Egg Harbor Inlet, N. J.:

Wm. E. Chapman, Brooklyn, N. Y., $13,940.

John Olsen, Boston, Mass., $3,100.

Edward R. Lowe, New York city, $11,250.

Eben Morgan Stoddard, Norfolk, Va., $5,500.

Charles W. Johnston, Lewes, Del., $14,400.

Atlantic Dredging Co., New York city, $8,700.

Atlantic and Gulf Wrecking, Co., Somer's Point N. J., $1,040.

American Dredging Co., Philadelphia, Pa., $4,700.

Contract awarded to the Atlantic and Gulf Wrecking Co.

THE following is an abstract of the bids for dredging in Choptank River, Md., opened by General Wm. F. Smith, U. S. Agent:

Frank C. Somers, Philadelphia, Pa., 23½c. per cubic yards measured in scows.

Baltimore Dredging Co., Baltimore, Md., 30c. per cubic yard measured in place, and 25c. measured in scows.

Thomas P. Morgan, Washington, D. C., 37½c. per cubic yard,

Morris & Cumming Dredging Company, New York city, 19½c. per cubic yard deposited on banks, and 21c. for material carried away.

The contract is awarded to Morris & Cumming Dredging Company.

THE following is an abstract of the only bid received for construction and maintenance of works relating to the improvement of Pensacola Harbor, Fla.:

Hugh B. Hatton, Pensacola, Fla., for construction, brush mattresses, $1.75 per cubic yard · piling, $5.25 per pile; rock ballast, $7.50 per cubic yard; lumber, $19 per m. feet b. m.; nails, spikes and bolts, 6½c. per pound.

For maintenance, brush mattresses, $2 per cubic yard; piling, $5.50 per pile; rock ballast, $7.50 per cubic yard; lumber, $20 per m. feet b. m.; nails, spikes and bolts, 6½c. per pound.

Bid has been rejected, and authority given Captain Hoxie to continue the work by hired labor.

THE Chicago & Northwestern is new, says the Chicago *Times*, extending to Ogden, and possibly to the Pacific coast. The extension from Valentine, Nebraska, is progressing rapidly. The ninety miles of grading under contract will be finished this season, with the exception of some heavy cuts. Beyond the end of the contract, the route for fifty miles has been located, taking the line to White River. From that point a branch is being surveyed to the Black Hills. Ties are being received at Valentine for the extension to White River, and preparations are being made to lay about forty miles of track per month from the opening of spring to the close of the season. Preliminary surveys have been made as far west as Fort Fetterman, Wyoming.

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THE following is an abstract of the proposals for improving Savannah River, below Angusta, Ga., opened by Colonel Q. A. Gillmore:

Atkins & Hoffman, Savannah, Ga., fascines, 98c. per cubic yard; stone, $1.95, and gravel, $1.75.

E. H. Gaynor, Savannah, Ga., fascines, 93c. per cubic yard; stone, $2.31, and gravel, 47c.

J. E. Walter, Rochester, N. Y., fascines, $1.40 per cubic yard; stone, 2.85, and gravel $2.85.

A. J. Howell, New York City, fascines, $1.87 per cubic yard; stone, $2.47, and gravel, $1.09.

Contract awarded to E. H. Gaynor.

THE following is an abstract of the last proposals received for removing wrecks in New Orleans harbor. The work was advertised twice before and the bids received were rejected, being considered excessive:

American Dredging Company, Philadelphia, steamship Gresham, $19,500; Ailsa, $6,500; General Grant, $6,500.

Atlantic and Gulf Wrecking Company, Somers Point, N. J., Gresham, $16,000; Ailsa, $6,000; General Grant, $6,000.

Edward R. Lowe, New York city, Gresham, $19,000; Ailsa, $9,500; General Grant, $9,500.

Rittenhouse Moore, Mobile, Ala., Gresham, $15,000; Ailsa, $8,000; General Grant, $8,000.

P. E. Falconer, Chicago, Ill., Gresham, $24,000. No bids on other vessels.

Contract awarded to the Atlantic and Gulf Wrecking Company.

THE following is an abstract of the proposals for building a new hospital at Deer Island received by the board of directors for public institutions of Boston, Mass.:

J. Sears, $65,400.
Hiram Ames, $59,734.
Andrew Anderson, $52,000.
J. McNamara, $49,524.
N. S. Wilbur, $48,913.
Woodbury & Leighton, $48,775.
J. Rawson, $48,469.
McNeil Brothers, $46,990.
A. and J. McLaren, $46,800.
E. Shapleigh, $45,359.
J. C. Hosmer, $44,040.
Creesy & Noyes, $44,037.
Hamilton & Parks, $42,833.
Wm. J. Jobling, $40,630.
C. J. Carmody, $28,838.
The contract was awarded to Wm. J. Jobling.

THE bids for the superstructure of the Kingsbury Run Viaduct Cleveland, O., were recently opened by the Board of Improvements. For the iron superstructure, not including hand-rail, eight bids were received as follows: Jersey Steel & Iron Co., of Trenton, N. J., $70,018; Cleveland Bridge & Iron Co., $79,100; King Iron and Bridge & Manufacturing Co., $66,695; Berlin Iron Bridge Co., New Berlin, Conn., $99,990; J. W. Walker, Pittsburg, $66,400; Detroit Bridge & Iron Works, $83,800; Pittsburg Bridge Co., $73,000; Union Bridge Co., Buffalo, $68,994.

The bids for the hand-rail were as follows: Cleveland Bridge & Iron Co., $4,825; King Iron and Bridge & Manufacturing Co., $4,000; Berlin Iron Bridge Co., $4,990; J. W. Walker, $4,400; Lowe's Forge & Bridge Works, Cincinnati, $4,850; Detroit Bridge & Iron Works, $4,815; Manly & Co., Manufacturing Co., Philadelphia, $4,413; Pittsburg Bridge Co., $4,750; Union Bridge Co., $4,500. The King Iron Bridge & Manufacturing Company have been awarded the contract by the Common Council.

THE following is an abstract of proposals for rock excavation and dredging in Taunton River, Mass., opened by Lieutenant Colonel Ernst:

J. H. Fenner, Jersey City, N. J., ledge, 366 cubic yards, $21.75 per cubic yard; boulders, 180 cubic yards, $5 per cubic yard; dredging class H, 1,600 cubic yards, 95c. and $1.15 per cubic yard; dredging class S, 13,500 cubic yards, 35c. and 30c. per cubic yard. Gross amount of bid, $14,724.05. Dredging material, classes H and S, above Berkley Bridge, $1.15 per cubic yard.

Richard M. Payn, Albany, N. Y., ledge, $29 per cubic yard; boulders, $7 per cubic yard; dredging class H, $1.48 per cubic yard, and class S 30c. Gross amount of bid, $18,292. $2 extra for class H above Berkley Bridge, and $4 extra for class S.

P. Sanford Ross, Jersey City, N. J., ledge $25 per cubic yard; boulders, $12 per cubic yard; dredging class H, $1.25 per cubic yard, and class S, 55c. Gross amount of bid, $20,735; 10c. extra for dredging classes A and S, above Berkley Bridge.

Solon S. Andrews, Biddeford, Me., and Thos. Symonds, Leominster, Mass., ledge, $26 per cubic yard; boulders, $8 per cubic yard; dredging class H, $3.50 per cubic yard, and class S, 42c. Gross amount of bid, $22,226; $2 extra for dredging above Berkley Bridge.

Contract awarded to Mr. Fenner.

THE following is an abstract of the proposals for dredging in Savannah harbor and river, Ga.:

Jacob Paulsen, Savannah, Ga., harbor and river, 19c. per cubic yard; Burden channels, 49c. per cubic yard.

American Dredging Company, Philadelphia, Pa., 24c. per cubic yard for harbor and river; no separate bid on Burden channels.

Colonel Gilmore thinks bids too high and withholds recommendations for the present.

PROPOSALS for estimates for dredging at the following named places on the North and East Rivers: Piers at West Seventeenth street; pier at West Eighteenth street; pier at West Nineteenth street (north side); pier at West Twenty-first street; pier at West Thirty-fourth street: pier at West Thirty-fifth street; pier at West One Hundred and Twenty-ninth street; pier at West One Hundred and Fifty-second street; slip between piers 56 and 57, E. R., will be received at the headquarters of the Dock Commissioners, 117 Duane street until November 19. See City Record.

ACCORDING to a German paper, the inventor of lucifer matches was a political prisoner who perfected his idea in 1833, within the walls of a State prison. Kammerer was a native of Ludwigsburg, and when sentenced to six months' imprisonment at Hohenasperg, he was fortunate enough to attract the notice and to gain the favor of an old officer in charge of the prison, who, finding he was studying chemistry, allowed him to arrange a small laboratory in his cell. Kammerer had been engaged in researches with a view of improving the defective steeping system, according to which splinters of wood, with sulphur at the ends, were dipped into a chemical fluid in order to produce a flame. If the fluid was fresh the result was satisfactory, but as it lost its virtues after a time, there was no general disposition to discontinue the old-fashioned system of using flint and steel. After many failures Kammerer began to experiment with phosphorus, and had almost completed his term of imprisonment when he discovered the right mixture and kindled a match by rubbing it against the wall of his cell. On coming out of prison he commenced the manufacture of matches. Unfortunately the absence of a patent law prevented his rights from being secured, and on Austrian and other chemists analyzing the composition, imitations speedily made their appearance. In 1835 the German States prohibited the use of these matches, considering them dangerous. When they were made in England and sent to the continent these regulations were withdrawn, but too late to be of any benefit to the inventor, who died in the mad house of his native town in 1857.

THE following is an abstract of the proposals for levee repair work, Yazoo Front, Mississippi River:

John A. Cannon, Greenville, Miss., Riverton to Hughes, earthwork, 21c. per cubic yard; tuft sodding, 2½c. per square yard; solid sodding, 8c. per square yard. Clay and Baggott to Easton earthwork, 25c.; tuft sodding, 2c.; solid sodding, 12c. One bid informal. He requested to withdraw the bid as he had made an error in filling it.

John J. Cooney, Memphis, Tenn., Riverton to Hughes, earthwork, 26c.; tuft sodding, 1½c. solid sodding, 6c. Clay and Baggott to Easton earthwork, 23 3-4c.; tuft sodding, 1c.; solid sodding 9c.

Joseph C. Neely, Bardwell, Ky., Riverton to Hughes, earthwork, 33c.; tuft sodding, 1½c. solid sodding, 3½c.

Clay and Baggott to Easton, earthwork, 33c.; tuft sodding, 1½c.; solid sodding, 3½c.

Dabney and Gray, Greenville, Miss., Riverton to Hughes, earthwork, 29½c.; tuft sodding, 1c.; solid sodding 10c.

Clay and Baggott to Easton, earthwork 28½c.; tuft sodding, 1c.; solid sodding, 10c.

Robert Johnson, Memphis, Tenn., Riverton to Hughes, earthwork, 29c.; tuft sodding, 1½c.; solid sodding, 3c.

Clay and Baggott to Easton, earthwork, 29c.; tuft sodding 1½c.; solid sodding, 3c.

J. L. Perkins, Riverton, Miss., Riverton to Hughes, earthwork, 23c.; tuft sodding, 1c.; solid sodding, 9c.

Wm. C. P. Jones, Rosedale, Miss., Riverton to Hughes, earthwork, 22c.; tuft sodding, 1c.; solid sodding, 3.

L. C. Dulaney, Rosedale, Miss., Riverton to Hughes, no bids. Clay and Baggott to Easton, earthworks, 23c.; tuft sodding, 1c.: solid sodding, 9c.

Absalom F. Bray, Memphis, Tenn., Riverton to Hughes, earthwork, 24½c.; tuft sodding, 1½c.; solid sodding, 13c. Clay and Baggott to Easton, earthworks, 24½c.; tuft sodding, 1½c.; solid sodding, 13c.

Contract awarded to W. C. P. Jones, for work from Riverton to Hughes, and to L. C. Dulaney from Clay and Baggott to Easton.

THE following is an abstract of the bids for pier extension at Cedar River Harbor, Michigan, opened by Lieutenant Colonel J. W. Barlow. We first give the materials required, and immediately following the aggregate prices of the bidders:

Material.

16,250 round piles other than white oak.
75,000 feet b. m. Norway sheet piling.
30,750 feet b. m. white oak timber.
1,000 linear feet of pine timber, 12×12.
1,500 linear feet b. m. pine timber, 6×12.
5,000 feet b. m. pine plank.
Stone, 560 cords.
13,000 pounds screw bolts and tie rods.
600 pounds spikes.

Aggregate Prices.

Canfield & Chapman, Watkins, N. Y., $12,012.50.

Olaf A. Norman, Escanaba, Mich., $13,350.

Schwarz & Berner, Green Bay, Wis., $10,130.50.

Truman & Cooper, Maintowac, Wis., $10,491.

Hanson & Scove, Maintowac, Wis., $10,860.25.

Contract awarded to Schwarz & Berner.

THE following is an abstract of the proposals for dredging and for furnishing piles, lumber, gravel, brush, binding poles, bolts, and spikes, for the improvement of the Appomattox River, Va., opened by Captain F. A. Hinman:

Wm. F. Gatling, Petersburg, Va., gravel, 46c. per cubic yard; brush, $1.44 per cord; binding poles, 4½c. each.

A. F. Hall, New York City, dredging, 13½c. per cubic yard.

P. Sanford Ross, Jersey City, N. J., dredging, 14½c. per cubic yard.

Morris & Cummings Dredging Company, New York City, dredging 25c. per cubic yard.

Thomas P. Morgan, Washington, D. C. dredging, 13, 9, 10c. per cubic yard.

Simon West, Petersburg, Va., piles, $1.05 each; gravel, 23c. per cubic yard; brush. $1.45 per cord; binding poles, 20c. each. No signature to bids; no guarantee; no justification; no certificate.

James Caler & Son, Norfolk, Va., dredging, 29c. per cubic yard.

No bids were made on lumber, bolts, or spikes, and authority has been given to purchase the same in open market.

The bids on piles and gravel have been rejected as excessive.

The brush and binding poles have been awarded to Wm. F. Gatling.

Contract for dredging awarded to A. F. Hall.

THE following is a synopsis of the bids for stone and brick work of basement and superstructure of the post office building at Terre Haute, Ind., received by Supervising Architect Bell and opened in his office, October, 31:

E. R. Brainerd & Co., Chicago, Ill.—Ohio buff sandstone; Basement to top of water table, $5,190; superstructure, $32,210; total, 37,400. Bedford limestone; Basement, $5,434; superstructure. $34,552; total, $39,986. Did not bid on brick work.

Andrew Dall, Jr., Cleveland, Ohio—Ohio blue sandstone; Basement, $5,699; superstructure, $33,398; total, $39,986. Did not bid on brick work.

S. C. Beach, Terre Haute, Ind.—No bid on stone work. Brick work; Basement, $2,863.66; superstructure, $11,502.21; total, $14,365.87.

J. W. Miller, Terre Haute.—No bid on stone work. Brick work: on basement, $3,448; superstructure, $11,604; total $15,052.

John Moore, Syracuse, N. Y.—No bid on stone-work. Brick work; Basement, $3,300; superstructure, $12,700; total, $16,000.

Indiana Oolitic Limestone Company, Terre Haute, Ind.—Indiana Oolitic Limestone; Basement, $6,812; superstructure, $32,655.40; total, $39,467.40. Brickwork; Basement, $4,044; superstructure, $12,936; total, $16,980.

Terre Haute Stone Work Company—Basement, Putnam limestone and superstructure, Indiana Oolitic limestone; Basement, $7,500; superstructure, $38,500; total, $46,000. No bid on brick work.

Hallowell Granite Company, Bedford, Ind.—Bedford, Indiana, limestone; Basement, $9,554.50; superstructure, $44,800; total, $54,354.50. No bid on brickwork.

S. C. Kane, Cleveland, Ohio—No bid on stone work. Brick work; Basement, $4,785; superstructure, $12,950; total, $17,735.

The bid of E. R. Brainerd & Co., ($5,434) for Bedford, Indiana limestone for basement, and their bid ($32,210) for Ohio buff sandstone for superstructure, and the bid of S. C. Beach, (14,365.87), for brick work of the basement and superstructure, have been accepted. Error of $100 in addition.